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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

Reindeer Industry in Alaska	G. J. Lomen
The Herald—A New Type of Prune	L. R. Detjen
Race Assimilation	H. H. Laughlin
The Tree Dahlia of Guatemala	Wilson Popenoe
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Protective Coloration in Birds	F. A. Woods

ORGAN OF THE
AMERICAN GENETIC ASSOCIATION
WASHINGTON · D. C.
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Volume XI, Number 6 July-August, 1920

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks.

Its membership is composed of men of science, teachers, publicists, physicians, clergymen, parents, students, horticulturists, and breeders of live stock throughout the world.

The Association owns the JOURNAL OF HEREDITY, which is published monthly and sent to each member without additional cost. Every member is thus a part owner of the JOURNAL.

Membership imposes no burdensome obligations. The Association, which is cooperative in nature, welcomes assistance in research, but does not demand it. Members are invited to submit discussions of the results of their research, accompanied by new and unusual photographs. All papers received will be given full consideration by the editorial board.

Hundreds of members are engaged in collecting facts about inheritance, and making experiments to determine the laws of heredity. Their discoveries are of fascinating interest and far-reaching importance to the city dweller and the country dweller alike. These findings are being reported and discussed every month in the JOURNAL, and in no better way can serious minded people keep abreast of one of the greatest movements of modern science.

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THE AMERICAN GENETIC ASSOCIATION

Box 472, Eleventh Street Station Washington, D. C.

The

Journal of Heredity

(Formerly the American Breeders' Magazine)

VOL. XI, NO. 6 JULY-AUGUST, 1920

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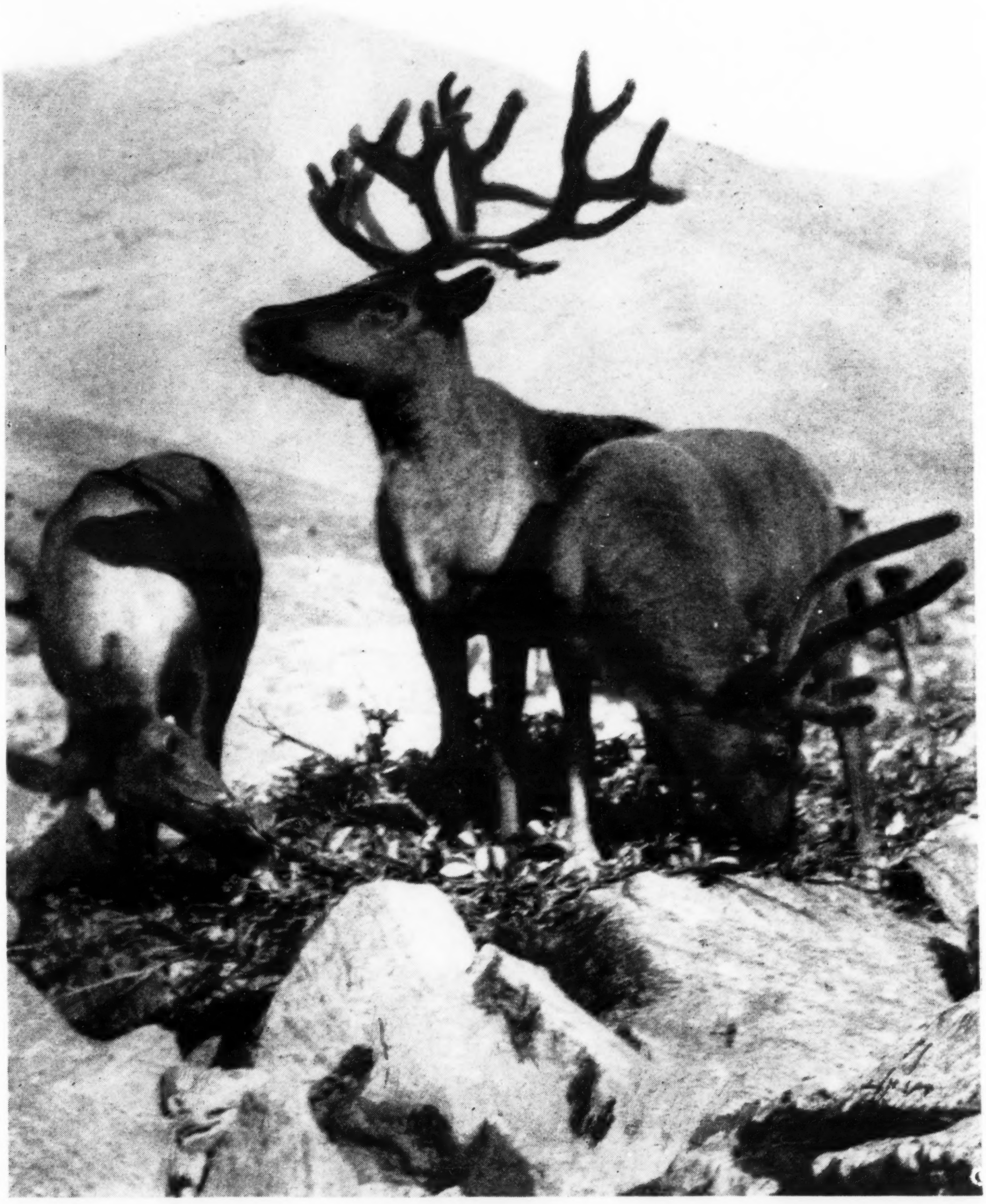


"IN THE VELVET"

A trio of reindeer summer brousing. This remarkable photograph was taken within a few miles of Cape Prince of Wales, Alaska, the westernmost extremity of the North American continent. While the antlers are growing they are said to be "in the velvet," because of the soft membrane and velvety fur in which they are enclosed. An authority estimates that Alaska can sustain a population of 100,000 people with 2,000,000 head of reindeer. Note the "swallow fork," a slit in the ear of the middle reindeer which is an ownership mark. Photograph by Lomen Bros., Nome, Alaska. (Frontispiece.)

THE REINDEER INDUSTRY IN ALASKA

In a Region Not Favorable to the Introduction of Cattle and Sheep, a Great Domestic Animal Industry is Being Built with Reindeer, Furnishing Food, Clothing and Labor to the People of the Far North

G. J. Lomen, LL.B.
Nome, Alaska

OUR national holiday, July 4th, 1892, auspiciously marked the beginning of the reindeer industry in Alaska. On that day, and for ten years thereafter, domestic reindeer to the total number of 1280 were imported by the Government, all of them from Siberia. Those imported from Norway were not breeders. The former were primarily imported for the relief and industrial education of the natives, the Eskimos; the latter were intended for the relief of starving miners at Circle City.

These imported reindeer have increased and multiplied most satisfactorily. From the small beginning above mentioned, they now number at least 200,000, notwithstanding the fact that about 100,000 have been killed for food and skins. At the present ratio of increase Alaska should have 10,000,000 reindeer in less than twenty years.

The ownership of the domestic reindeer of Alaska is held in the following proportions: About one thousand Eskimos own seventy percent; Lomen & Company (Inc.), ten percent; the Government, four percent; Missions, Lapps and others, sixteen percent. The ownership is designated by various earmarks. The general supervision of the industry, so far as the natives are concerned, lies with the Bureau of Education.

THE REINDEER'S CHARACTERISTICS AND HABITS

A brief review of the present status of the industry and a description of the species, the habits and characteristics of the animal will, it is hoped, be of interest to the readers of *The Journal of Heredity*.

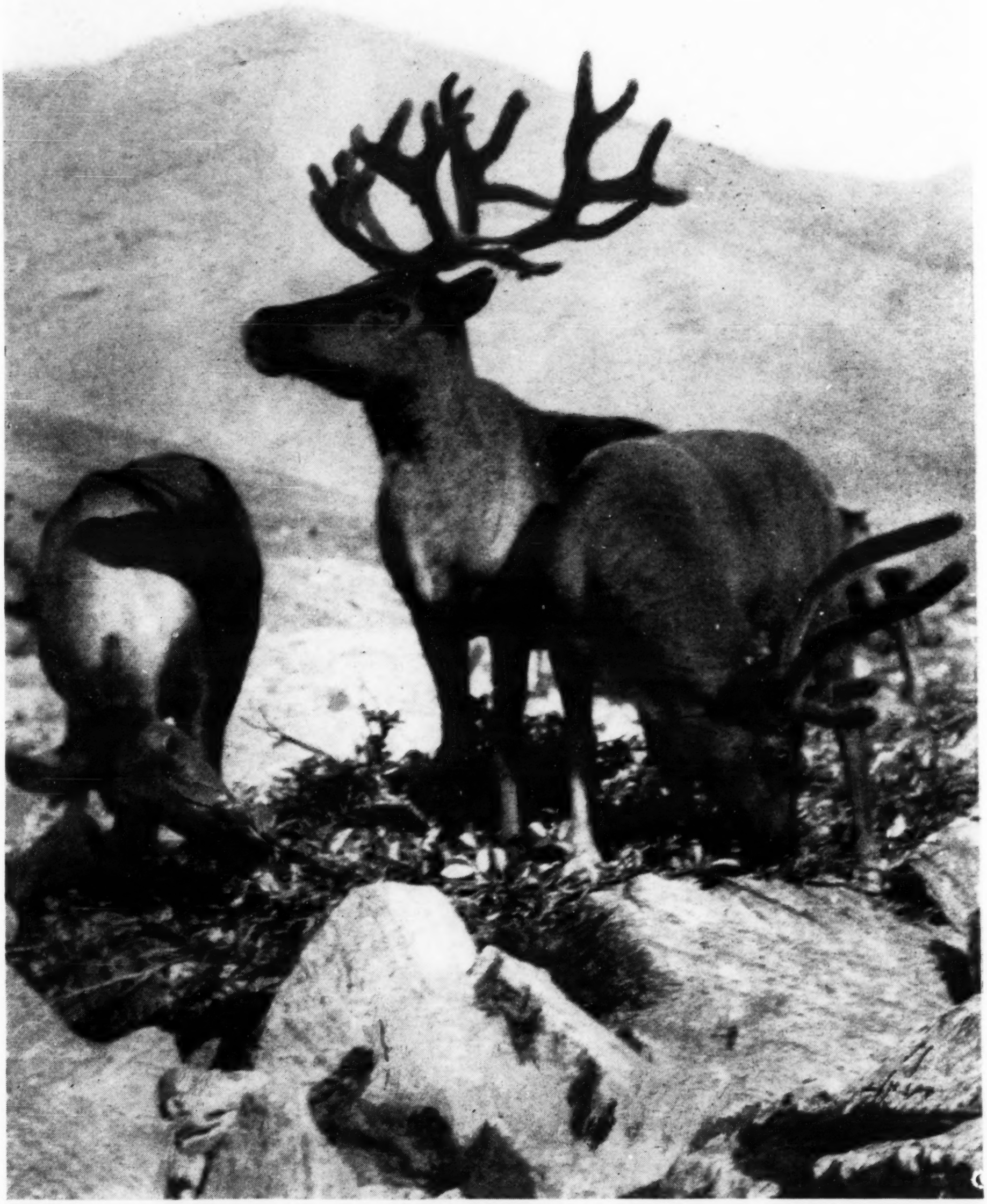
Until recently the reindeer industry has attracted but little attention, and little is known of the animal except in the far North; and yet the reindeer is the most widely distributed mammal in the world. Its habitat is circumpolar, embracing the tundras or barrens of the far North, and to a large extent the wooded districts farther south—a territory far exceeding in size all of Europe. Fossil remains show that the reindeer were once indigenous to latitudes farther south than at present.

The reindeer is the only member of the deer family that has been domesticated. This domestication, however, is limited in degree as compared with that of our other domestic animals. The reindeer remain in a semi-wild state, except those that are especially and more thoroughly tamed and trained for sled, draft or lead deer. To catch the animal it is generally necessary to use the lasso. Corrals and shutes are also used for this purpose, especially in the "marking season."

The caribou, the wild reindeer of North America, was never domesticated. An effort to domesticate them will, no doubt, be made in the near future; at least an effort will be made to cross them with domestic reindeer.

LITTLE CARE NECESSARY

Unlike other domestic animals the reindeer does not depend on man for food or shelter. In winter the reindeer feeds almost exclusively on mosses, especially the reindeer moss, *Cladonia rangiferina*, the nutritive qualities of



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A HERD OF REINDEER IN MID-WINTER

There are more than a hundred herds of reindeer in Alaska, and they vary in size from a few hundred animals to upwards of 10,000, occupying the west coast from Point Barrow to the Alaskan Peninsula. Reindeer were first introduced into Alaska from Siberia and Lapland in 1892. They have increased from a herd of 171 to nearly 200,000 at the present time, and it is estimated that there is a grazing area sufficient to take care of 10,000,000 of them. The animals can stand the severest weather, and depend upon grazing for all their food. Photograph by Lomen Bros. (Fig. 1.)

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CORRALLED AT GOLOVIN, ALASKA

The animals are corralled for the purpose of marking the fawns with an ownership mark. The modern method is to pass them through shutes or runways, thus eliminating the use of the lasso. The reindeer furnish the basis for a new industry which can easily supply Alaska with all the meat it needs besides great quantities for the United States. There has been much inbreeding among scrubby stock, but efforts will henceforth be directed toward improving the grade of the animals by crossing them with native caribou. Photograph by Lomen Bros. (Fig. 2.)

REINDEER FIND THEIR OWN FOOD

They live in the summer time on the moss and other vegetation on the Arctic plains and in winter paw through the snow to get the vegetation that is not exposed. The animal shown in the center is a female reindeer, one of the last of the original stock imported from Siberia. The photograph, by Lomen Bros., was taken near Kruzamapa Hot Springs. (Fig. 3.)

which depend chiefly on the gelatigenous and starchy matter of which it is largely composed. Its taste is slightly pungent and acrid. It is said, also, to contain tonic qualities. It is gray in color, and is the most common vegetation in the far North. In form it resembles branched coral. Other mosses constituting winter foods are: *Cetraria nivalis*, *Stereocaulon paschale*, *Cetraria islandica*, *Parmelia encausta*, *Parmelia saxatelia*. In spring and summer the reindeer feeds on grasses, willow leaves, buds, mushrooms, marine algae. These may be enumerated as: *Aira flexuosa*, *Aira alpina*, *Poa alpina*, *Salix hastata*, *Salix glauca*, *Salix herbacea*, *Menyanthes trifoliata*, *Mulgedium alpinum*, *Rumex acetosa*, *Oxsyria reniformis*, *Gentiana purpurea*, *Ranunculus glacialis*, *Dryas octopetala*, *Rubus chamaemorus*, the *Gyrophora species*, *Nefroma arcticum*, and grasses. Moss is also eaten, to some extent, in summer, but not when dry. In the fall the mushroom (*Boletus*, *Lycoperdon*, etc.) especially attract the animal. To raise reindeer on other vegetation or fodder would necessarily be experimental.

The reindeer is an antlered, herbivorous, graminivorous, ruminant ungulate, and a semi-migratory but gregarious animal, of the family *Cervidae*, the genus *Rangifer*, and the species *Rangifer tarandus*, which latter represents the type. Sub-species, depending on environment, have also been classified.

SIGNIFICANCE OF THE ANTLERS

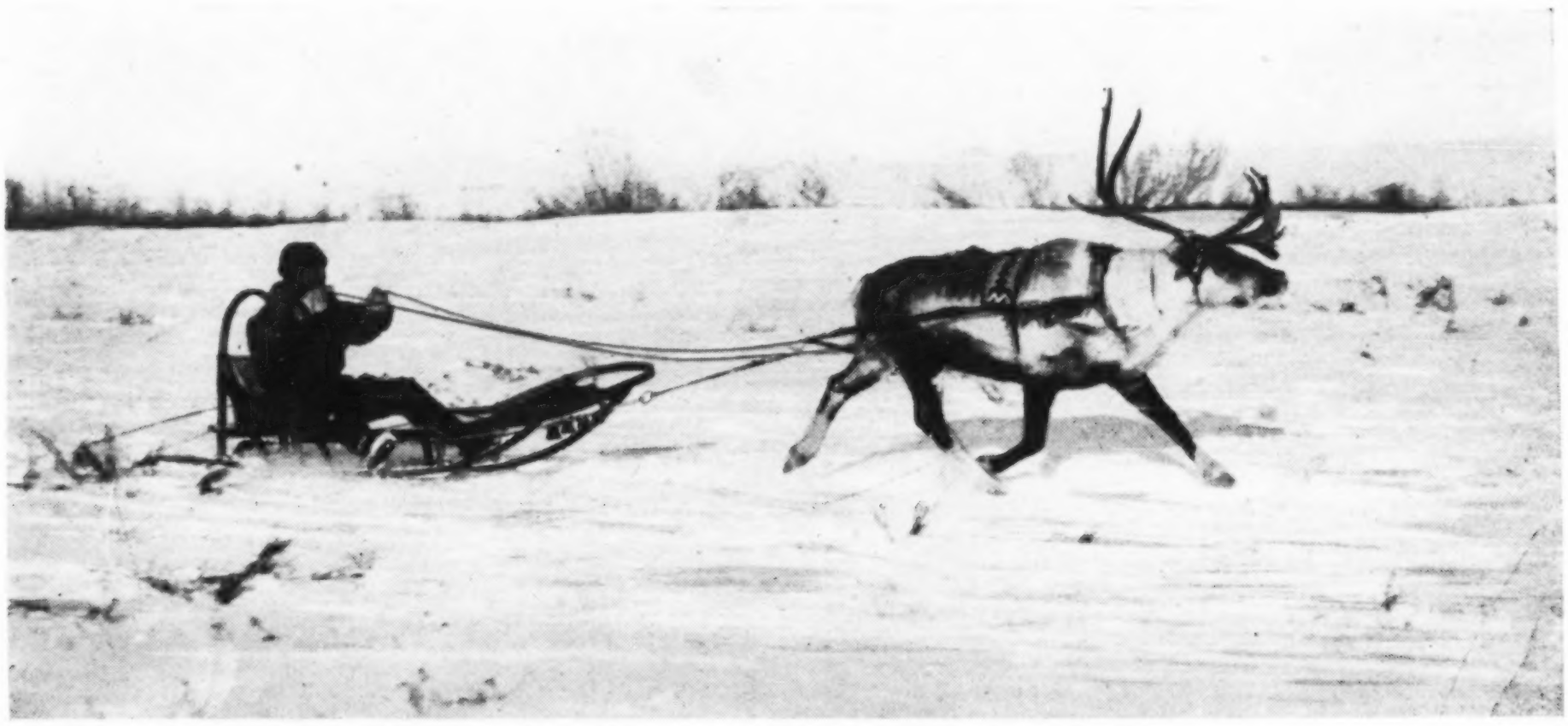
A full grown reindeer, three years old, stands about four and one-half feet high, and is about seven feet long from its nose to its tail.

The branched appendages to the skull of the reindeer, called antlers, though not as large or heavy as those of some other members of the deer family, are very large in proportion to the size of the animal—literally and figuratively its most outstanding feature. The beams of the antlers are

A CROSS BETWEEN A REINDEER AND NATIVE CARIBOU

It is a pleasure for the natives to drive the reindeer, especially in racing. A span of these animals is said to have made ten miles in twenty-eight minutes. The animal here shown was photographed at the start of a ten mile race. It is fifteen years of age, and is a cross between a reindeer and an Alaskan caribou—one of the finest specimens to be seen in the north country for size and symmetry of body. This illustrates the great possibilities for improving the animals by crossing with the caribou. Photograph by Lomen Bros. (Fig. 4.)

not altogether round, but partially flattened; in places they are nearly three cornered. The beams curve upwards and forwards and are surmounted with slightly palmated tines or prongs. They are supplied with brow as well as beztines. The antlers consist of nearly homogeneous tissue, lighter and more porous than ordinary bone. During their growth the antlers are enclosed in a soft membrane, which is covered with a velvety fur; they are, then, said to be "in the velvet." This membrane consists of a net-work of blood vessels which supply nutriment to the antlers. The antlers are claimed to be secondary "sexual characters." When the velvet has peeled off, in the months of September and October, the antlers are full grown. Then it is that mating time—the rut—begins. The reindeer are unique in that the antlers are common to both sexes, though slightly smaller in the female. The antlers are shed annually, grown up males shedding theirs before the fawning season, the females after that time, and then the fawns. This is providential and enables the weaker to protect themselves against the stronger, during the nurture of the young. The antlers are a protection, also, to the eyes of the animal during their duels, and when racing through underbrush. It is doubtful if dehorning would prove advantageous, but experiments are being made. The size, form and condition of the antlers determine the



REINDEER RACING IS AN ALASKAN SPORT

For exhibition purposes as many as ten reindeer have been driven to one sled, but usually one or two to a sled. Some remarkable records with one and two animals have been made for distances up to ten miles. There is a record of five miles in 14 minutes and 32 seconds, and one for 10 miles in 27 minutes and 30 seconds. Photograph by Lomen Bros. (Fig. 5.)

condition of the animal. Small antlers are a sign of deterioration. Sterile animals are said to be recognized by their straight antlers.

FEMALES NEVER KILLED FOR MARKET

The male reindeer is polygamous. During the rut he gathers his harem—this is a time of love and hate. The bucks then fight duels, often to death. The clatter of horns is continually heard. The antlers sometimes, but very rarely, become so interlocked that the animals cannot separate themselves. If help does not then arrive they will die of starvation.

The reindeer are not particularly prolific. The doe gives birth to one fawn each year—rarely two. Strong and early fawns sometimes breed when only one year old. The does continue to breed until fourteen or fifteen years of age. The reason for the rapid increase of the herds in Alaska is that females are never intentionally killed. The natives are prohibited from so doing, and other owners sufficiently appreciate the value of the does for breeding purposes, not to kill them. Bucks and steers, however, are killed for the market. Their elimination from the herds gives the does and fawns more latitude, less molestation, and more and better feed than they would otherwise have. The period of gestation is seven months and seven days. The herds should double every three years, allowing an annual kill of ten percent, without affecting such result.

VARIATIONS IN COLOR

The color of reindeer in summer is a chocolate brown; in winter it is lighter. Some reindeer are spotted, and some are white. None are wholly of one color. Their hair under the throat, belly, short stubby tail, on the muzzle and immediately above the hoofs, is white or nearly so. Under the throat the hair is very long and tufted, hanging like a pendant mane. The hair of the reindeer is hollow and hence very buoyant.

One of the peculiarities of the reindeer is that it has no gall-bladder. This, however, is said to be common to all of the *Cervidae*. Other peculiarities are that the animal, when running, pants like a dog. Instinctively it travels against the wind; and, in "milling" runs or swims "against the sun." The so-called "dew-claws" of the reindeer are functional—being of use to the animal as a brake in going down snow clad hills, and they assist in supporting the animal on the deep snow

A NEW ARRIVAL

This little reindeer fawn is less than one day old. The doe gives birth to one fawn each year, rarely two, and continues to breed until fourteen or fifteen years of age. Females are never intentionally killed for the market, the bucks and steers being taken for that purpose. Photograph by Lomen Bros. (Fig. 6.)

A WHITE REINDEER FAWN

A cold reception usually awaits the reindeer fawn as the season of fawning opens early in April and extends through May. Fawns like this are often born in the snow with the temperature sometimes as low as 35° below zero. Photograph by Lomen Bros. (Fig. 7.)

and soft mossy tundras where it frequents. The hoofs proper, on account of the great spread of the toes, further assist to support it.

The olfactory powers of the animal enable it to detect the mosses on which it feeds, however much buried under the snow; and its strong legs and sharp hoofs enable it to uncover the food.

THE REINDEER'S HOMING INSTINCT

The animal's power of orientation is remarkable. It *knows* its pastures and i s range, its home, and, like a homing pigeon, while it does not fly, "treks" back to its range when removed therefrom, unless restrained by watchful herding, or, until it becomes familiar with its new environments—acclimated, so to speak. The latter takes a year or more.

When walking the reindeer produces a peculiar crackling sound, occasioned by sinews just above the fetlock. Many have ascribed this sound to the clicking of the toes of the animal; others, to a small bone above the quick of the hoof. This sound, as well as an oily substance that exudes from a gland between the toes of the animal, are thought to be a system of sound and scent signals. The Lapps claim that the reindeer "oils its horns" with the exudations of the gland and can "shape the antlers." It is indeed often seen to rub its horns with one of its hind hoofs. This is, however, probably due to a itching sensation produced by developing tines, and not an oiling or shaping process.

The call of the reindeer is a peculiar grunt or bark, difficult to represent orthoepically; perhaps "uhrrr," pronounced gutturally and with a quick expulsion of the breath, would answer. This call is continually heard in a large herd while the fawns are young—the mother calling the fawn or vice-versa. It is also heard when the buck is calling or belling the doe.

The pelage of the reindeer is such as to protect the animal from freezing in the most inclement weather or cold. However, sudden and extreme cold, after a rain, or after a thaw, is a severe test, and is often disastrous, especially to the young animals. Such weather conditions often cause the starvation of large numbers, because of the icy coating and crust it produces, encasing or covering the mosses.

WIDE NATURAL RANGE NECESSARY

On account of the apparent necessity for a change of food, and to avoid the fly and mosquito pests, the reindeer, in summer, seek new pastures, preferably the sea shore, but also high altitudes. They also seek sheltered fawning places. In feeding they travel long distances, nibbling as they go. Thus, their natural range necessarily becomes extensive. Close herding, too, is detrimental to the animal and to the pasturage.

SCIENTIFIC BREEDING EXPERIMENTS TO BE UNDERTAKEN

The reindeer of Alaska have suffered somewhat from inbreeding, due to the difficulties of supplying new blood. Now, that Congress has appropriated funds for the establishment (by the Bureau of Biological Survey, Dr. E. W. Nelson, Chief) of an Experimental Station at or near Unalakleet, Alaska, it is hoped that this difficulty will, in part, be overcome by the crossing of reindeer with caribou, importation of new stock and an interchange of bucks among the herds. It is also hoped that greater attention will be directed toward relieving the animals of disease and pests that afflict or infest them, and that measures will be taken to cause the extermination or control of predatory animals that kill or injure them. These are especially bears, wolves, lynx and eagles. Dr. Nelson's assistants, Dr. Seymour Hadwin and Mr. L. J. Palmer, are already on the ground, and find a large field for discovery and experiment. Their report will surely be interesting.

The reindeer is used for food, clothing and transportation. It has been said of the animal that "it is valuable to the last hair." It is rare sport to drive the animal. In racing, a span of reindeer has made ten miles in twenty-seven to twenty-eight minutes.

CLOTHING FOR THE NATIVES

Reindeer were first introduced into Alaska to assist the natives to become self-supporting, and the animals now furnish the people of the far north with food, clothing and transportation. Trained veterinarians and animal husbandmen are needed to study and advise methods of control of reindeer diseases and to teach the Eskimos how to maintain their herds and improve the quality of the stock. Photograph by Lomen Bros. (Fig. 9.)

ON THE TRAIL, PILGRIM RIVER, ALASKA

The grading up of the reindeer into larger animals producing more meat can be readily brought about by crossing them with the native caribou from the interior of Alaska. Plans for scientific breeding have already been begun by the U. S. Department of Agriculture. The progress and usefulness of the reindeer in Alaska have greatly impressed the Canadians, and their government has undertaken a study of the industry with a view to its development in its own extensive grazing areas. Photograph by Lomen Bros. (Fig. 10.)

EXPORTATION OF REINDEER MEAT AND SKINS

The reindeer industry in Alaska has already reached a stage where it more than supplies the local demand, and exportation of meat and skins is being conducted by the firm of Lomen & Company.

The principal difficulties encountered by this company have been the necessity of making long, expensive and hazardous drives, in order to bring the animals to shipping points, equipped with cold storage plants (Nome, Keewalik and St. Michaels), and shipping the carcasses thence to market. Refrigerator boats have also been few and far between.

To relieve this situation this company is now building two additional cold storage plants, one at Golovin and one at Egavik, and plans are made to build at other stations in the near future. Under the present conditions the season's shipments will not exceed two thousand carcasses, averaging one hundred and fifty pounds each. Each year will see this quantity largely increased, depending quite as much upon the improvement in shipping facilities as on an increase in the growth of the herds.

A reduction statistically of the live stock of Sweden into "cattle units" gives the following result: one head of horned cattle is estimated as equal to two-thirds horse, = ten sheep, = twelve goats, = four pigs, = five reindeer. These units are interesting for purposes of comparison.

The reindeer industry will go far to solve the meat problem of the country, to reclaim the waste places of the territory, and help to conserve to the hunter and the epicure the wild game animals. All of which is of the greatest importance, considering that reindeer meat, or venison, is equal to, if not superior to all other venison, and a splendid substitute for beef and mutton.

THE HERALD[1]—NEW TYPE OF PRUNE

L. R. DETJEN

Delaware College and Agricultural Experiment Station, Newark

THE commercial prune which is now grown so abundantly in the Pacific Northwest finds its origin in a group of European plums collectively known as *Prunus domestica*. No other species or group of plums, so far as the writer is aware, has ever before produced fruit that might properly be termed a prune. A variety, however, has recently been discovered which seems to disclaim all specific relationship with any of the European species. It presumably originated from one of the native American species, probably from that of *Prunus munsoniana* (Wight and Hedrick) and, notwithstanding this fact, it dries, cures and keeps indefinitely. Fresh specimens of fruit of this Herald prune, gathered on July 7, 1916, were laid away in the laboratory in cloth bags, and later, when air-dried, they were placed in a bottle with a tight-fitting cork stopper. Here they are today, after a period of three and one-half years, in as good condition as when first stored. The aroma from this fruit is pleasant and not unlike that of the common commercial product.

The original tree of the Herald variety was discovered in 1916 growing in the garden of Mr. W. F. Marshall of Raleigh, N. C., under the name of Milton plum. That is the name under which the owner had purchased the tree five or six years earlier from the Stark Bros. Nursery, Louisiana, Miss. The tree apparently belongs to the *Prunus munsoniana* species, of which the Milton is said to be a variety. It was critically studied for signs of hybridity with *Prunus domestica*, but no such traces, outside of the prune character, were observed. The variety seems to have originated from the native American species without any trace of foreign blood; and this is the most interesting feature of its account.

GENERAL DESCRIPTION OF THE VARIETY

In habit of growth the tree is spreading and has all of the bark, leaf, bud and flower characteristics pertaining to the Wild Goose group of plums. The fruit taken from the original tree measures from 30 to 35 mm. in length and 28 mm. in width. In general, it might be said to be oblong in shape and bright red in color, with a light coat of blue bloom. The dots are large, white and very numerous. The flesh is yellow, soft, juicy, sweet, and clings tenaciously to the pit. The stem, unlike that of other native species, clings to both branch and fruit, which fact prevents the latter from dropping to the ground as soon as ripe. The fruits on the tree are not crowded but hang free in the sunshine and wind, where they shrivel and dry naturally, after which they can be easily gathered and thoroughly cured indoors.

The pits from the original tree measure about 20 mm. in length, 12 to 14 mm. in width and 8 to 9 mm. in thickness. The surface is smooth and their shape is that of typical prune pits, that is, with one of the edges depressed and the other more rounded. All of the above measurements and descriptions are of the original tree and fruits. A remarkable difference was noted in the fruit taken from scions top-grafted to another species of plum, *Prunus angustifolia*.

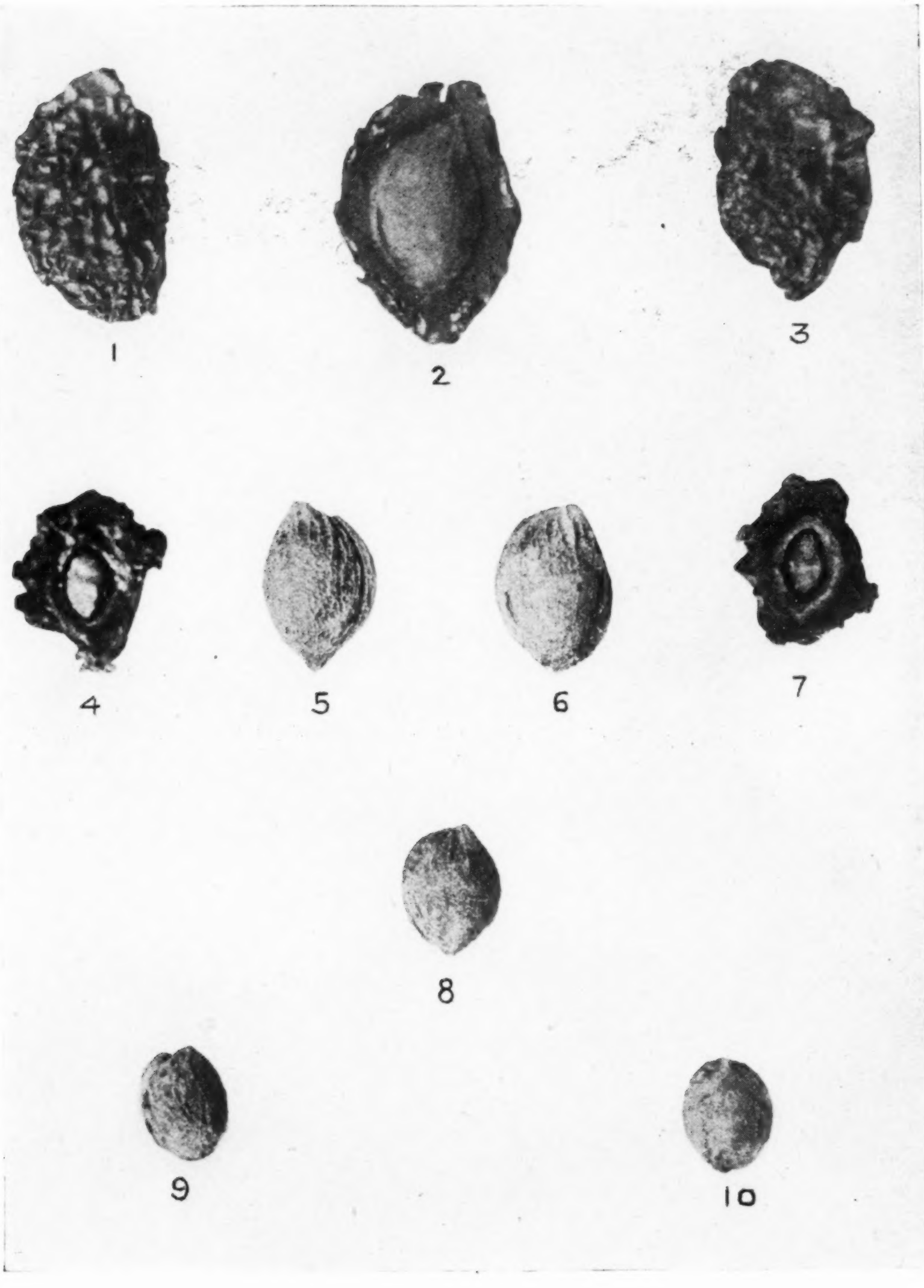
COMPARISON OF HERALD PRUNE WITH MILTON PLUM

In the spring of 1917, scions from the original Herald prune tree were procured, and top-grafted 6 feet high to a *Prunus angustifolia* tree. Scions of the Milton variety of plum were also secured during the same year from the

[1] This new variety I have named the "Herald" because, although utterly worthless in itself as a prune, it may be the forerunner heralding a new strain for eastern America.

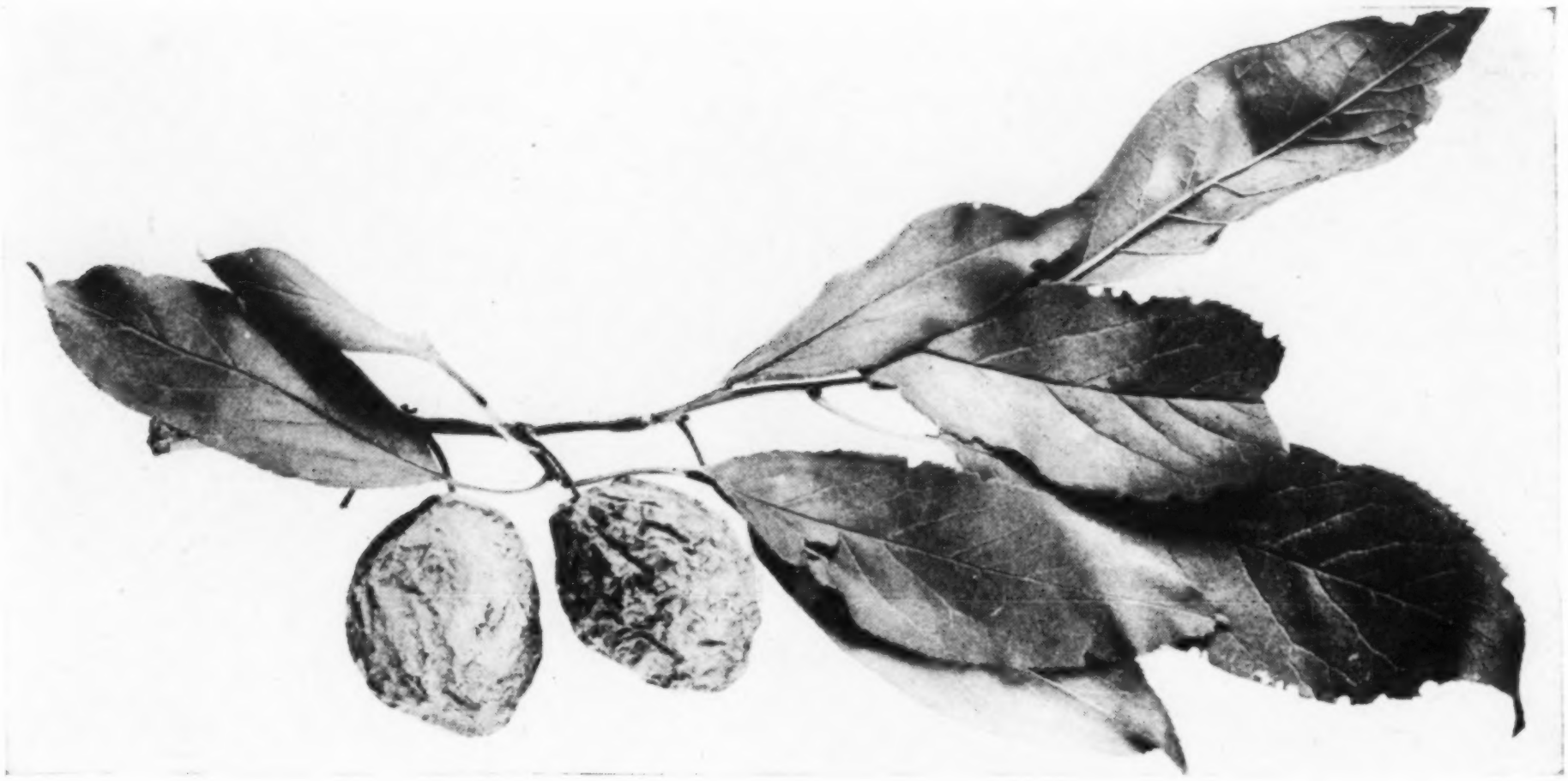
BRANCH OF HERALD PRUNE TREE IN FULL BLOOM

The original tree of this variety was discovered in a garden in Raleigh, North Carolina, growing under the name of Milton plum—the name by which the owner had purchased it in Louisiana six years before. Study of its prune characteristics gives evidence that it originated from native American species. (Photograph reduced.) (Fig. 11.)



FRUITS OF THE HERALD PRUNE

Nos. 1 and 3 are side views of Herald prunes three and one-half years old. No. 2 shows one of the prunes cut lengthwise to compare the size of the pit with the amount of flesh. Nos. 4 and 7 show the halves of the prune when cut transversely. Nos. 5 and 6 are two typical pits of the Herald variety. No. 8 shows the pit of a Herald prune when top-grafted to *Prunus angustifolia* stock, and Nos. 9 and 10 are typical pits from the *Prunus angustifolia* stock, natural size. Note the intermediate size between Nos. 5 and 6 and 9 and 10. (Fig. 12.)



BRANCH OF THE HERALD PRUNE WITH TWO DRIED FRUITS

This branch was taken from the original tree. The fruits do not readily drop to the ground when ripe, but cling to the branches where they are not crowded, and they dry naturally in the sun. Photograph reduced. (Fig. 13.)

Indiana Agricultural Experiment Station, through the courtesy of Prof. H. J. Reed, and top-worked for the sake of comparison to the identical *Prunus angustifolia* tree. Every graft of both varieties grew and later produced fruit. It was soon noticed that the Herald prune is a less vigorous grower, and this is verified by numerous trees on similar stock root-grafted during the same season. The leaves are somewhat smaller both in length and width, the bark is more brown, even on the under or shady side of the branch, and the fruit buds develop more abundantly on the new wood. The flowers on Herald scions, which were forced in water in the greenhouse, as well as those that were produced in 1918 and 1919 on the top-worked tree, show quite a distinct difference from those of the Milton variety that were similarly forced and grown. The limb of the corolla of the Milton flower measures on the average about 13 mm. while that of the Herald flower measures 17 mm. The individual petals of the latter also show correspondingly increased measurements.

A heavy frost occurring on March 10, 1918, destroyed most of the flowers of both varieties and, of those that escaped, many were destroyed by curculio injury. However, one normal prune and six normal plums were secured, and from these the following comparisons were made. Five of the Milton variety were ripe and had dropped on June 16, with their stems remaining attached to the tree, while the last of sixth fruit ripened and dropped as late as June 29. The Herald variety ripened its fruit with the fruit of the Milton plums, but clung to the tree and had begun to shrivel when the last of the Milton variety dropped, and then it actually had to be detached. The plums soon deteriorated in the laboratory while the prune shriveled and cured easily. The fruits of both varieties are practically the same in color and consistency. The plums are slightly longer than they are broad, while the prunes are more oblong in shape. The dots on the plum are decidedly more numerous on the upper half, while on the prune they are distributed quite uniformly all over the fruit. Both varieties are of the clingstone type, but the pit of the prune is larger in all dimensions than that of the plum. The Herald prune scions seem to make an uncongenial union with *Prunus angustifolia*, for the entire lot of those that were top-worked—six

FRUITS FROM THE ORIGINAL HERALD PRUNE TREE

The fruit at the left is ripe and turgid like a plum in its prime. The one at the right is dry and shrivelled like a prune. The two central fruits show conditions at different stages of drying. Photograph natural size. (Fig. 14.)

BRANCH FROM ORIGINAL HERALD PRUNE TREE

The fruits are scattered over the tree and hang free to dry naturally in the sunshine and wind. Note that the outermost fruit at the right is turgid and ripe while the two fruits to the left of it are beyond the plum stage and have begun to shrivel. (Fig. 15.)

in all—had but a brief existence and died while blooming in the spring of 1919. They died for no other apparent reason than that of uncongeniality of stock, while all of the Milton plum s ions, a'so six i n number, seems as vigorous today as ever. Even this brief comparison would readily indicate the two samples of fruit are of distinctly different varieties.

THE EFFECT OF STOCK ON SCION

It will be of general interest to note at this time what effect a different stock, *e. g.*, *Prunus angustifolia*, exerts on the Herald variety of prune, and undoubtedly a similar effect might be observed on other varieties of plums and prunes when so united. The fruit from the top-worked tree measures 5 mm. less in length and 4 mm. less in width than that from the original tree. The pit also lacks 3 mm. in length, 1 mm. in width and a fraction of a millimeter in thickness. Its surface is velvety, like that of the pits of the *Prunus angustifolia* species, while the surface of the pits from fruits taken from the original tree is hard and less velvety. Again, the characteristic prune-shaped pit is much less pronounced; in fact, it greatly resembles those of the *Prunus angustifolia* species.

As the original Herald prune tree was purchased for the Milton variety of plum from a reliable nursery, and as no such prune variety had knowingly been propagated by that nursery, one is led to believe that a mutation arising from the native *Prunus monsoniana* species has occurred. The tree is supposed to be budded stock, but whether this is true or whether the bud died in the nursery and a root mutation has actually occurred—in other words, whether the tree is growing on its own roots or on those of another variety—cannot be determined at this time. The most interesting feature of this variety seems to be that a true prune, one that will dry on the tree and cure perfectly without removing the pit, although of no commercial value as a prune, has developed from one of our native American species of plums.

Great as our interest may be in such a discovery, it must be remembered, of course, that this particular variety, because of its soft texture and juicy flesh, cannot be expected to compete with any of those of the commercial prune, *i. e.*, of the *Prunus domestica* species. Not until a great amount of work has been done in hybridizing this new Herald prune with the better commercial sorts can we hope to be rewarded by virtue of such a discovery. In the south, where the *Prunus domestica* species cannot easily be grown because of climatic conditions and fungus diseases, this late blooming and apparently highly resistant native prune might be utilized in hybridization work to make possible the growing of a new strain of prune for eastern America.

A Contribution to Eugenics

PERSONAL BEAUTY AND RACIAL BETTERMENT, by Knight Dunlap, professor of experimental psychology in the Johns Hopkins Hospital, Baltimore. Pp. 95, price $1. St. Louis, C. V. Mosby Co., 1920.

True personal beauty is the best single guide to sound sexual selection, according to Professor Dunlap; and he develops this point with plausible ingenuity, although without any statistical basis. The second part of the book is an essay on applied eugenics. Dr. Dunlap does not favor sterilization, does favor segregation, and believes much could be accomplished by proper propaganda of birth-control.

The book is filled with interesting and penetrating ideas, with most of which eugenists will agree. It is written simply and readably, and is worth reading. It deserves to be very widely circulated.—P. P.

RACE ASSIMILATION BY THE PURE-SIRE METHOD

HARRY H. LAUGHLIN, SC.D.
Assistant Director, Eugenics Record Office

WHILE it has been demonstrated to the satisfaction of students of pedigrees that in most species the ancestral contributions of the dam and the sire are about equal, still on account of physiological and social considerations the pure-sire method is much more potent than a possible pure-dam method would be in race improvement. The principal reason is that physiologically the reproductive capacities of the race are limited, not by the number of fertile sires, but by the number of fertile dams. But in the human race almost equally potent is this social or mate-selection factor whereby the women of the lower races usually show a preference for men of higher racial levels. Furthermore the *mores* of most states cast less social obloquy upon the fathers than upon the mothers of an illegitimate child, and similarly less reproach is directed toward a legitimate mating between a man belonging to a "high" race and a woman of "inferior" blood than toward the reverse type of marriage.

RACE-MIXTURE IN EARLY SPANISH-AMERICA

In historic times we have interesting examples of race improvement or assimilation by a process which is quite analogous to the pure-sire method with which we are familiar in the animal kingdom. In the early days of Spanish America, there were many more men than women who came from the mother country and settled in the new world. The result was that there began almost immediately a process of race-mixture which was quite lacking in the regions settled by the northern European colonists. In the latter case the immigration to the new world consisted largely of colonists and their families who came into a comparatively unsettled country in search of new homes, whereas in the case of Spain, the conquistadors—armies of men alone—came seeking wealth, adventure and colonial possessions.

From the social side, we find in the new world this situation: the average Spaniard, or man with considerable Spanish blood, would of necessity, on account of the scarcity of Spanish women, have to remain a bachelor or marry a wife with less Spanish blood on the average, than he himself carried. The result was, from the standpoint of the Spaniard, that his offspring were of less pure Spanish descent, while from the standpoint of the native Indian or imported negro, the offspring were of a decidedly higher racial level.

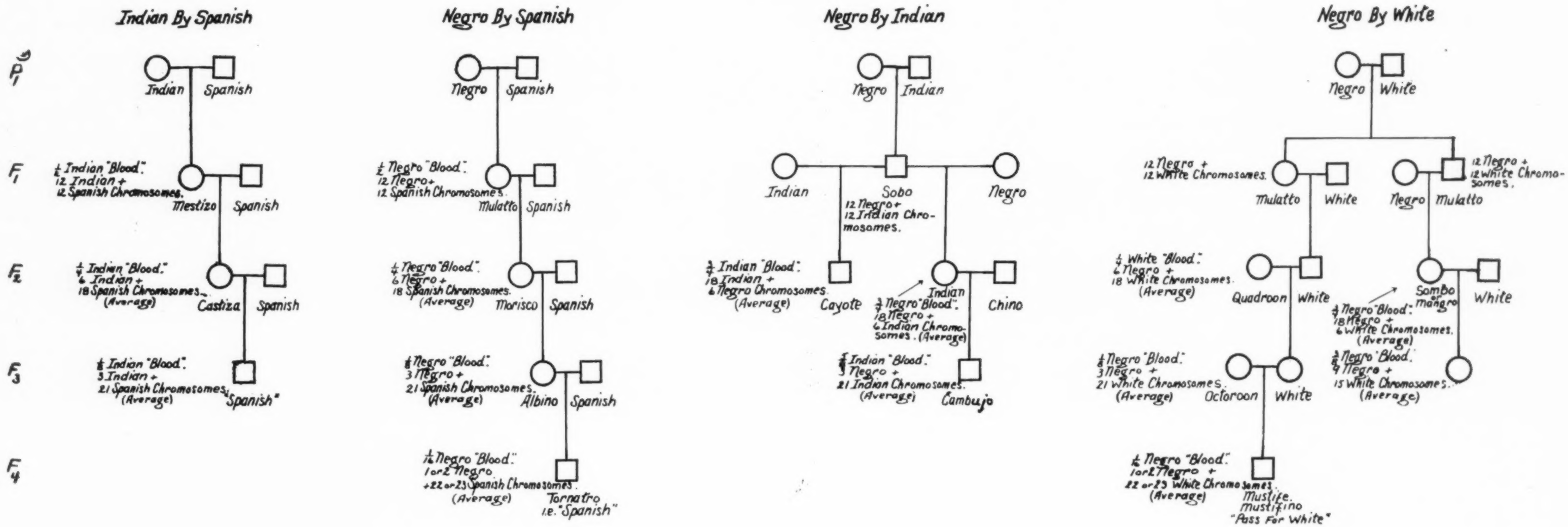
EFFICACY OF THE PURE-SIRE METHOD

It appears that a man with "a touch" of Indian or negro blood could return to Spain with his Spanish father and enter Spanish society much more readily than could a daughter with Indian or colored blood. The process of race assimilation by the pure-sire method became so common in Latin America that there developed a definite system of nomenclature[1] for describing the products of each particular generation of offspring. The accompanying pedigree-chart shows this process in detail, and attention is called to the sureness with which race assimilation is achieved by clinging to the pure-sire method, whereas in case this system is dropped, confusion results and a mixed race is the product.

The efficacy of the pure-sire method is doubly assured when we remember that in man, as in other animals, the germ-plasm is not indefinitely dilutable, but segregates into chromosomes which in their entirety (barring crossing-over) either do or do not pass from a given ancestor to the offspring. We shall not go into this matter here,

[1] J. Deniker, The Races of Man, 1913, p. 542.

The Pure Sire Method Of Race Assimilation in America.



In Spanish America *In Spanish America* *In Spanish America* *In Jamaica*

A pedigree chart illustrating the process of race assimilation by the pure-sire method. "In the early days of Spanish-America, there were many more men than women who came from the mother country and settled in the new world. The result was that there began almost immediately a process of race mixture which was quite lacking in the regions settled by the north European colonists." It was necessary for the man of Spanish blood to "remain a bachelor or marry a wife with less Spanish blood on the average than he himself carried." The diagram above indicates the system of nomenclature which became necessary to describe the offspring of each generation. (Fig. 16.)

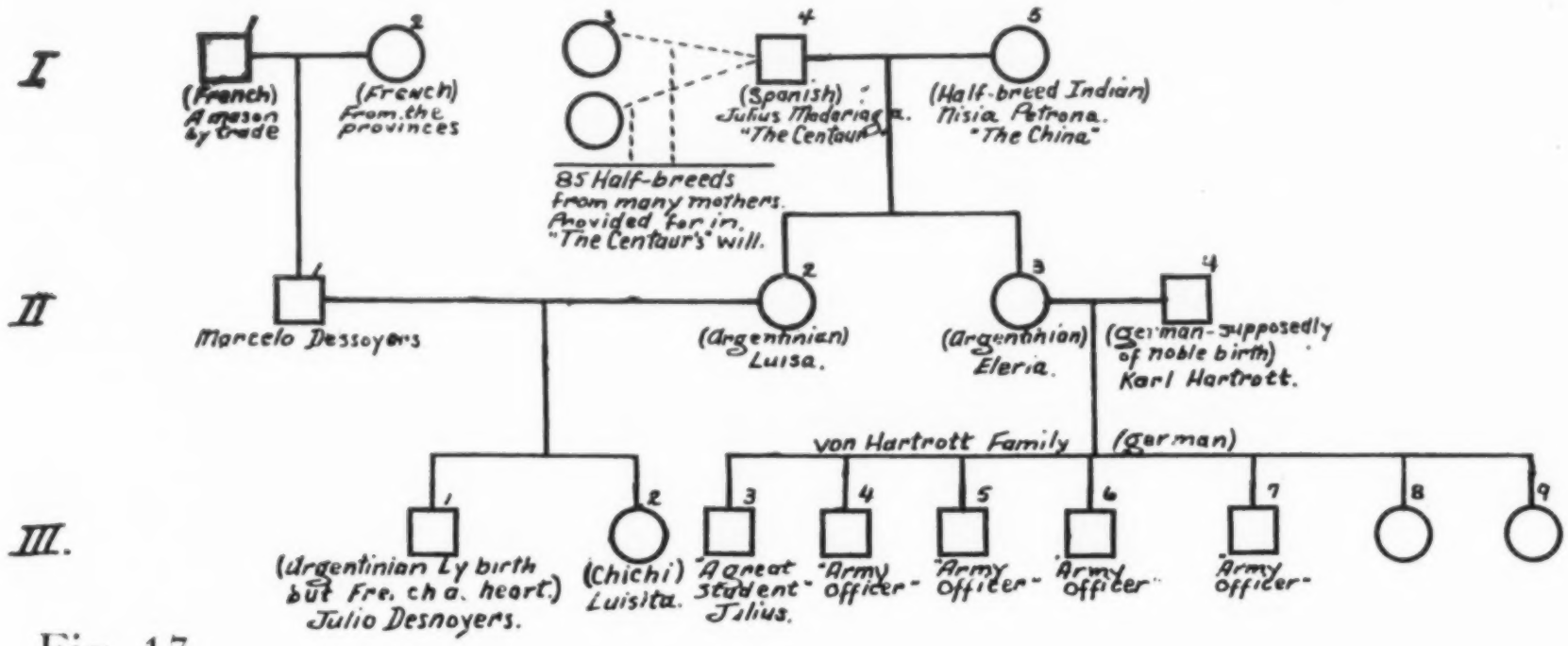


Fig. 17

Pedigree Chart from "Four Horsemen of the Apocalypse," by Vincente Blasco Ibañez.

but we know that on the average one out of every 4,096 human beings that we see has entirely eliminated the ancestral chromosomes of his or her mother's mother, and one out of 2,048 his or her father's mother.[2] In such cases there is not even a "touch" of that particular grandparent's "blood" remaining. It requires just as many generations of pure-sire assimilation to eliminate the "blood" of an ancestor of one race as of another; for example, it would take just as long for a mixed "pass-for-English" family to "breed-out" its French or its German ancestry as it would to rid itself of its negro or Chinese "blood." But practically, because of the many basic qualities common to closely related races, the apparent racial assimilation is, in such cases, often completed in one or two generations. In these cases some foreign "blood" persists, but it is "not so very foreign," so that if supported by social assimilation, the transfusion, for all practical purposes, is quite complete.

A NOVELIST'S ILLUSTRATION

Vicente Blasco Ibañez claims (and his claim is generally credited) that in his novels he portrays social and scientific facts in a much more reliable manner than the ordinary imaginative novelist uses. In "The Four Horsemen of the Apocalypse"[3] he gives the story of a Spanish-American family which, by the pure-sire method, "bred up" the descendants of a half-breed Indian woman ("The China"), first to Argentinians; then through one daughter, by marriage with a Frenchman, we find in one more generation children "passing-for-French," and through the second daughter, who married a German, von Hartrott, the children "pass-for-German." The pedigree-chart diagramming this family is given in this article not because it is a pedigree of an actual family, but because it is a type-pedigree on which history, sociology and anthropology place the stamp of accuracy. A writer with wild rather than a constructive imagination, and with less knowledge of history for a background, would not have built his story on a pedigree so typical of the true situation.

JEWS MIX WITH OTHER RACES

But whenever two races come into close contact for a long period of years, race-mixture is certain to result. Even the Jews,[4] who claim to have preserved a certain racial purity from ancient times, are found to mix with the people of each territory which they occupy.

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[2] Harry H. Laughlin, Calculating Ancestral Influence in Man: A Mathematical Measure of the Demonstrated Facts of Bi-Sexual Heredity. In press in "Genetics."

[3] Vicente Blasco Ibañez, The Four Horsemen of the Apocalypse (Fiction). American translation 1918.

[4] Redcliffe N. Salaman, M. D., Heredity in the Jew. The Eugenics Review, pp. 187–200, Vol. III, 1911–12.

"In the family-tree here plotted, there are two persons of half-Jewish blood, three of one-quarter Jewish blood, and two with no Jewish blood at all." (Fig. 18.)

Thus we speak of German-Jews, or even of Chinese-Jews.[5] In each case the so-called Jew presents a mixture of those traits which we think of as typically Jewish with those of the race among which the particular Jewish strain is living. Thus we must think of the Jews as an institution and a society as well as a race. Their racial traits may constitute the principal background of Judaism, but that is not the whole story.

In the accompanying picture of a Jamaican family is found a case of Negro-Jews. In the family-tree here plotted, there are two persons of half-Jewish blood, three of one-quarter Jewish blood, and two with no Jewish blood at all. The observer can, if he be keen, locate in the picture those with and those without Jewish blood. This particular family, due doubtless to the infusion of Jewish traits, was much more successful socially and economically than the average Jamaican family with an equivalent proportion of other but less socially competent white blood.

[5] Maurice Fishberg, The Jews, 1911, p. 134.

ONE TYPE OF RACE MIXTURE IN JAMAICA, B. W. I.

(School Children in the Town of Moneague.) See the text below for explanation. (Fig. 19.)

BLENDING OF RACIAL TRAITS

Another picture here shown is of three children from a school in a Jamaican town. The boy to the left is a Hindu[6] coolie with no negro blood in his veins, although his skin is as black as that of the average quarter-blood negro. His features, however, do not disclose any negroid traits. The boy to the right is a "Sambo,"[7] that is of three-quarters black and one-quarter white blood. The little girl in the centre is descended from a Hindu coolie father and a "Sambo" mother. Here we see racial traits blending. This blend is especially noticeable in the hair, the nose and the lips. So potent is the pure-sire[8] method of race assimilation that should this girl, her daughters and her granddaughters marry Hindu co lies, doubtless the racial transformation would be complete in that direction; or if, on the other hand, she and her daughters and granddaughters were to marry "Jamaicans," the assimilation of her descendants by the latter race would be equally complete.

CONCLUSION

The data given in this article are isolated but th y are representative facts from the mass of anthropological evidence which demonstrates the general fact that whenever two races come into intimate contact the upper race tends to remain pure while the lower tends toward assimilation into the upper, by the pure-sire system. Thus the expression "the salvation of a great nation is the virtue of its women" is true racially as well as socially and morally. So long as the basic instincts and the social ideals of mankind remain as they are today, and have been since man first appeared, racial evolution and assimilation will tend toward the race-types of men which the women of the particular nation choose as mates.

[6] On March 31, 1918 there were 20,206 East Indian immigrants in Jamaica. They are brought in principally to work on the sugar plantations.

[7] Chas. B. Davenport, Heredity of Skin Color in Negro-White Crosses, 1913, p. 27.

[8] Harry H. Laughlin, The Relation between the Number of Chromosomes of a Species and the Rate of Elimination of Mongrel Blood by the Pure-Sire Method. Proceedings of the Society for Experimental Biology and Medicine, 1919, xvi., pp. 132–134.

TYPICAL WILD FORM OF THE TREE DAHLIA

It is in this form—a tall plant producing lilac-pink single flowers—that *Dahlia maxoni* occurs in the highlands of Guatemala. When brought into cultivation it gives rise to double-flowered varieties of several shades of color. The stem here shown was cut and photographed by the roadside on the slopes of the Volcan de Agua, near Antigua, Guatemala. (Fig. 20.)

THE TREE DAHLIA OF GUATEMALA

WILSON POPENOE
Agricultural Explorer, United States Department of Agriculture

RIDING through the Guatemalan highlands in the months of December or January, the traveler is certain to be impressed with the beauty of the wild tree dahlia whose starry, lilac-pink flowers, in graceful clusters upon long slender stems, break the somber monotony of a dark green hillside in a most effective manner. And as he enters one of the picturesque Indian villages of the highlands, particularly if he be so fortunate as to find himself in the town of Tactic, he is sure to be enchanted by the flowering hedges of this plant which surround the diminutive gardens of the people.

SUITABLE FOR SUB-TROPICAL AREAS

Why has not the Guatemalan tree dahlia become more widely known horticulturally? A plant at once so beautiful, so conspicuous in its native home, and so readily propagated should be one of the first to be carried to other lands; yet *Dahlia maxoni* (such is the name under which the species is now known) seems never to have become widely distributed. Probably this is due to the fact that its climatic requirements fit it for cultivation only in the mildest parts of the sub-tropics, or in the tropics at elevations sufficiently high to temper the heat. When planted in northern gardens, it is cut down by frost before it has had an opportunity to come into flower, though in favored situations in southern California it has occasionally bloomed gorgeously. In Florida, if the proper soil conditions can be provided, it should prove successful. And certainly there are many places in northern India, in southern Japan, in sub-tropical Brazil, and numerous other countries where it would find congenial surroundings, and where it would prove an excellent addition to the list of garden plants.

To the Kekchi Indians of northern Guatemala, this dahlia is known as *tzolokh*, while those who speak the Pokonchi language call it *shikor*. Spanish-speaking Guatemalans usually term it *Santa Catarina*. Though extremely abundant, both wild and cultivated, in many parts of the Guatemalan highlands (principally between 3,000 and 7,000 feet elevation) it seems never to have received much attention from botanists; indeed, W. E. Safford, of the U. S. Department of Agriculture, last year found that it had not yet received even a name, hence he described it as *Dahlia maxoni*, in honor of William A. Maxon, of the U. S. National Herbarium.

FOUR DISTINCT FORMS

When I first saw this plant in Guatemala during the winter of 1916-17, I felt immediately that it was worthy of horticultural attention. Still more was I impressed with its possibilities when I found what appeared to be four distinct forms of the species; the type, which is single-flowered and lilac-pink in color; a single-flowered white variety, identical with the type except in color; and two double-flowered varieties—one lilac-pink and one white. I sent cuttings of these double-flowered forms to Washington, where they were propagated but later lost by freezing, and I took home with me photographs of them. From my description of the plant, and from photographs, Mr. Safford thought the double-flowered form so distinct from the type that he did not include it in his description of *Dahlia maxoni*.

Upon returning to Guatemala, and again seeing the tree dahlia in bloom, I have been able to satisfy myself that the double-flowered varieties have their origin in the single-flowered, typical form, and properly belong to the same species.

As a wild plant, upon the mountainsides removed from cultivation, I have never seen any other than the typical form, with eight lilac-pink ray-florets

THE TREE DAHLIA IN CULTIVATION

The double-flowered forms which originate in cultivation are propagated by cuttings and planted in gardens or hedgerows. The huge size to which the plants may grow is shown by this row along a fence in Tactic, Guatemala. This variety is lilac-pink in color. (Fig. 21.)

THREE FLOWERS FROM A SINGLE PLANT

The origin of double-flowered varieties by bud-sporting or mutation is illustrated by the three flowers shown in this illustration. All of them were taken from the same plant, growing in a hedgerow at Tactic, Guatemala. The flower on the left is single, practically the same as those produced by wild plants; the one in the center is an intermediate, while on the right is one which has become fully double. (Fig. 22.)

and a compact group of small yellow disk-florets. Sometimes the stems reach 15 or even 18 feet in height, and become quite woody toward the base. They terminate in a number of slender branches, each bearing several flowers, not all of which open at one time. The flowers face outwards and upwards, one of the characteristics which distinguishes this species from *D. imperialis*. The flowers of the latter are distinctly nodding.

When brought into cultivation around the huts of the Indians the species seems to lose its stability. In place of single lilac-pink flowers other forms often appear, and since the plant is readily propagated by cuttings it is a simple matter to reproduce these variations. The single white variety is relatively rare, and iis flowers are much in demand among the Indians for decorating the images of saints which all of them keep in their homes. The double white is somewhat more abundant, and the double lilac-pink is perhaps the commonest of all the variations from the type. I have seen all of these forms both in northern Guatemala (Tactic and Coban) and in the central part of the country, near Antigua.

WIDE RANGE OF FORM AND COLOR

It is evident that the double-flowered forms originate as bud-sports from the single ones, for I have found numerous plants, both in northern Guatemala and near Antigua, on which there were flowers of both types, as well as intermediate forms. Figure 22 shows three flowers from a single plant growing in a hedgerow at Tactic, Alta Verapaz. On the left is the typical flower with eight ray-florets, and numerous minute yellow disk-florets closely crowded together. In the center flower many of the disk-florets are no longer small and yellow, but have become more like the ray-florets in character and similar in color—lilac-pink in this instance. In the flower on the right, the disk-florets are still larger, and the flower has become quite double. Even in the double-flowered form, however, the ray-florets can be distinguished from the altered disk-florets. In the flower shown in the photograph, the ray-florets appear in the rear, larger and broader than the rest. While the typical, single-flowered form produces fertile seed in abundance, I have been unable to find any seed produced by the double-flowered varieties.

The largest flowers, whether single or double, measure four or five inches in diameter. In the double-flowered forms there are various shades of color. I have seen a bright lilac-pink—almost a pure pink; a deep lilac-pink; and a darker shade which could almost be called a mauve.

The wide range of form and color which horticulturists have obtained from the several species of Dahlia cultivated in the north is familiar to everyone. Varieties have been produced both by crossing, and through the vegetative propagation of forms which originated as bud-sports. The only defect of *Dahlia maxoni*, from the northern horticulturist's point of view, is the long growing season which it requires in order to reach the flowering stage. But will it not be possible, by crossing this species with some of those now cultivated in the north, to produce interesting and valuable forms which will be successful under practically the same conditions as the cactus and other groups of cultivated dahlias? Certainly a species which grows to eighteen feet in height, and which exhibits a strong tendency to produce handsome double-flowered sports, will not be without interest to American dahlia breeders!

CHLOROPHYLL FACTORS OF MAIZE

Their Distribution on the Chromosomes and Relation to the Problem of Inbreeding.[1]

E. W. LINDSTROM
Department of Genetics, University of Wisconsin

IT IS a significant fact that the great majority of heritable characters known in maize are recessive to the normal type in inheritance. Such characters as *dwarfness*, *ramosa* ear, *liguleless* leaf, chlorophyll characters such as *white*, *virescent-white*, and *yellow* seedlings, *golden*, *green-striped*, *Japonica*, *fine-striped*, and the *lineate-leaved* plants are all simple Mendelian recessives to the common or normal type of maize. Disregarding aleurone, pericarp and endosperm characters, since one is not certain as to what is normal in those respects, only one character, pod-corn, has been definitely shown to be dominant. Strangely enough this dominant character, pod-corn, is almost completely sterile in the homozygous dominant condition.

Most of these recessive characters influence the life and vigor of the maize plant directly. The presence of one of them often seriously affects the life and productivity of the plant. If any such abnormalities were dominant characters they would quickly perish in the struggle for existence without leaving a trace. Because they are recessive in inheritance they can be carried along from one generation to the next in normal appearing plants, heterozygous for the abnormal factors. This is obviously the reason for the presence of so many recessive characters and so few dominant ones in maize.

INFLUENCE OF RECESSIVE CHARACTERS

The relation between such recessive characters and the question of inbreeding is very intimate. Continued inbreeding of maize is nearly always followed by a decrease in stature, yield and fertility. This, together with the facts that the maize plant is normally in a heterozygous condition because of its method of open-pollination and that recessive abnormalities are abundant, at once suggests that the artificial inbreeding of maize merely isolates the recessive characters which are relatively poor in stature, yield or fertility.

Having once eliminated these poor characters by selective inbreeding, one might suppose that the remaining plants, being relatively free from such abnormalities, would now possess only the better characters. This, however, is true only to a very limited extent. The actual results of maize inbreeding have not been successful in producing such superior stock.

Apparently the reason for this is the influence of linkage on the distribution of characters. If one could eliminate most of the inferior characters without disturbing the favorable complex, the problem would be solved. But it seems that when we isolate and eliminate the poorer types by inbreeding, at the same time we discard some of the better factors that are correlated with the unfavorable ones in inheritance. Such a situation is expected from our present knowledge of the linkage relations of an organism.

It seems safe to assume that such favorable factors as influence size, yield, good quality, and fertility are multiple in nature and undoubtedly are distributed in all the ten pairs of chromosomes in maize. Certainly the facts of size inheritance appear to confirm this.

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[1] Papers from the Department of Genetics, Agricultural Experiment Station, University of Wisconsin, No. 22. Published with the approval of the Director of the Station.

Some of the original crosses reported in this article were made at the New York State College of Agriculture at Cornell University, Department of Plant Breeding.

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It is evident that the double-flowered forms originate as bud-sports from the single ones, for I have found numerous plants, both in northern Guatemala and near Antigua, on which there were flowers of both types, as well as intermediate forms. Figure 22 shows three flowers from a single plant growing in a hedgerow at Tactic, Alta Verapaz. On the left is the typical flower with eight ray-florets, and numerous minute yellow disk-florets closely crowded together. In the center flower many of the disk-florets are no longer small and yellow, but have become more like the ray-florets in character and similar in color—lilac-pink in this instance. In the flower on the right, the disk-florets are still larger, and the flower has become quite double. Even in the double-flowered form, however, the ray-florets can be distinguished from the altered disk-florets. In the flower shown in the photograph, the ray-florets appear in the rear, larger and broader than the rest. While the typical, single-flowered form produces fertile seed in abundance, I have been unable to find any seed produced by the double-flowered varieties.

The largest flowers, whether single or double, measure four or five inches in diameter. In the double-flowered forms there are various shades of color. I have seen a bright lilac-pink—almost a pure pink; a deep lilac-pink; and a darker shade which could almost be called a mauve.

The wide range of form and color which horticulturists have obtained from the several species of Dahlia cultivated in the north is familiar to everyone. Varieties have been produced both by crossing, and through the vegetative propagation of forms which originated as bud-sports. The only defect of *Dahlia maxoni*, from the northern horticulturist's point of view, is the long growing season which it requires in order to reach the flowering stage. But will it not be possible, by crossing this species with some of those now cultivated in the north, to produce interesting and valuable forms which will be successful under practically the same conditions as the cactus and other groups of cultivated dahlias? Certainly a species which grows to eighteen feet in height, and which exhibits a strong tendency to produce handsome double-flowered sports, will not be without interest to American dahlia breeders!

CHLOROPHYLL FACTORS OF MAIZE

Their Distribution on the Chromosomes and Relation to the Problem of Inbreeding.[1]

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IT IS a significant fact that the great majority of heritable characters known in maize are recessive to the normal type in inheritance. Such characters as *dwarfness*, *ramosa* ear, *liguleless* leaf, chlorophyll characters such as *white*, *virescent-white*, and *yellow* seedlings, *golden*, *green-striped*, *Japonica*, *fine-striped*, and the *lineate-leaved* plants are all simple Mendelian recessives to the common or normal type of maize. Disregarding aleurone, pericarp and endosperm characters, since one is not certain as to what is normal in those respects, only one character, pod-corn, has been definitely shown to be dominant. Strangely enough this dominant character, pod-corn, is almost completely sterile in the homozygous dominant condition.

Most of these recessive characters influence the life and vigor of the maize plant directly. The presence of one of them often seriously affects the life and productivity of the plant. If any such abnormalities were dominant characters they would quickly perish in the struggle for existence without leaving a trace. Because they are recessive in inheritance they can be carried along from one generation to the next in normal appearing plants, heterozygous for the abnormal factors. This is obviously the reason for the presence of so many recessive characters and so few dominant ones in maize.

INFLUENCE OF RECESSIVE CHARACTERS

The relation between such recessive characters and the question of inbreeding is very intimate. Continued inbreeding of maize is nearly always followed by a decrease in stature, yield and fertility. This, together with the facts that the maize plant is normally in a heterozygous condition because of its method of open-pollination and that recessive abnormalities are abundant, at once suggests that the artificial inbreeding of maize merely isolates the recessive characters which are relatively poor in stature, yield or fertility.

Having once eliminated these poor characters by selective inbreeding, one might suppose that the remaining plants, being relatively free from such abnormalities, would now possess only the better characters. This, however, is true only to a very limited extent. The actual results of maize inbreeding have not been successful in producing such superior stock.

Apparently the reason for this is the influence of linkage on the distribution of characters. If one could eliminate most of the inferior characters without disturbing the favorable complex, the problem would be solved. But it seems that when we isolate and eliminate the poorer types by inbreeding, at the same time we discard some of the better factors that are correlated with the unfavorable ones in inheritance. Such a situation is expected from our present knowledge of the linkage relations of an organism.

It seems safe to assume that such favorable factors as influence size, yield, good quality, and fertility are multiple in nature and undoubtedly are distributed in all the ten pairs of chromosomes in maize. Certainly the facts of size inheritance appear to confirm this.

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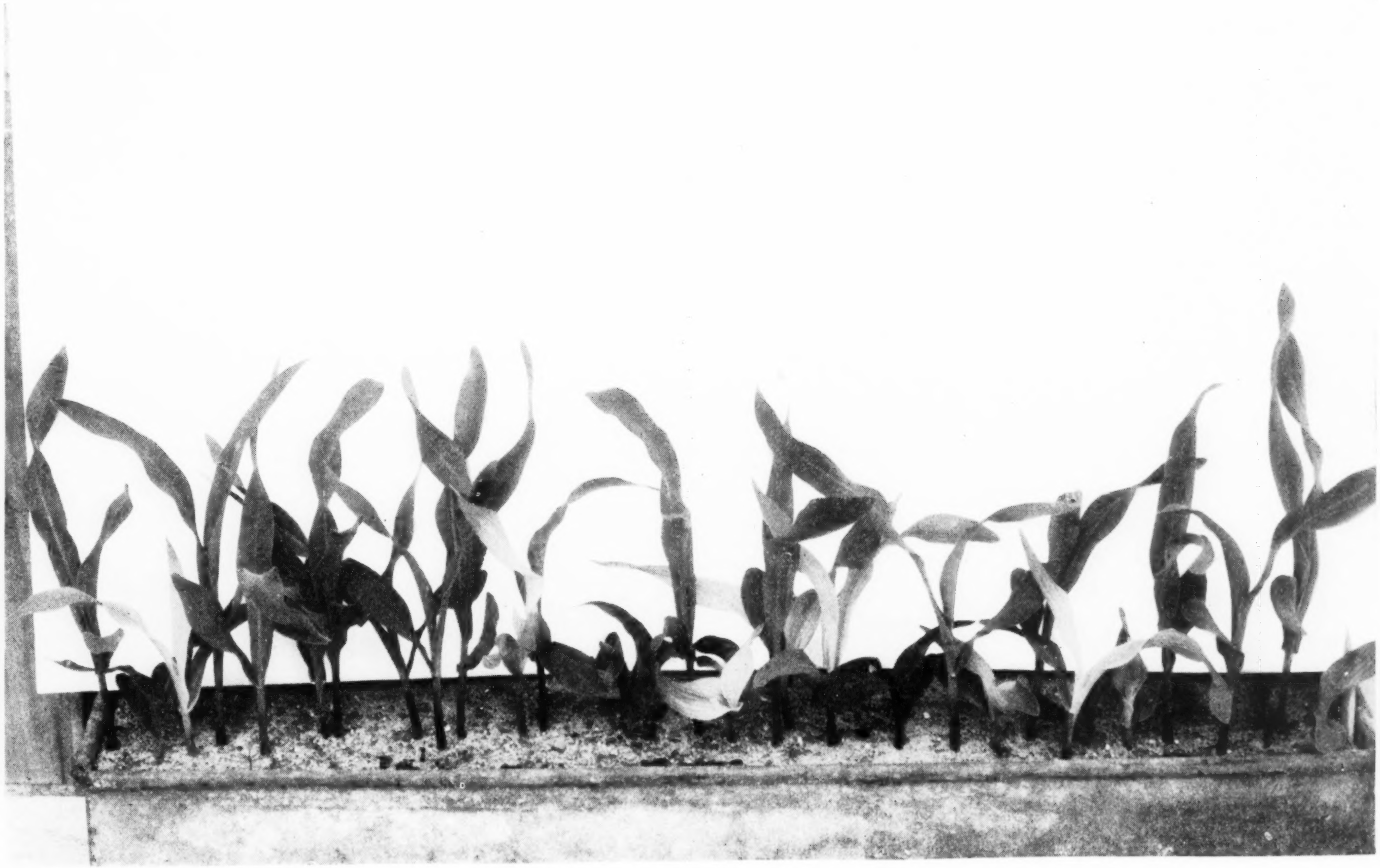
[1] Papers from the Department of Genetics, Agricultural Experiment Station, University of Wisconsin, No. 22. Published with the approval of the Director of the Station.

Some of the original crosses reported in this article were made at the New York State College of Agriculture at Cornell University, Department of Plant Breeding.



MAIZE SEEDLINGS

Showing segregation into tall green, tall virescent-white, dwarf green and dwarf virescent-white. In this particular row, these four types occur in the proportion of 16:5:6:4 respectively. "Dwarfness in maize is a simple Mendelian recessive to the tall normal type. The virescent-white character is also a simple recessive to normal green." (Fig. 23.)

EFFECT OF UNFAVORABLE FACTORS

But what of the distribution of the unfavorable factors in the chromosomes? If we can demonstrate that many factors causing a reduction in the vigor of the maize plant are distributed in many different chromosomes, it would add positive evidence to the present theory on the effects of inbreeding. It is the purpose of this paper to point out the distribution of some such unfavorable factors, especially those concerned with the development of chlorophyll.

Chlorophyll abnormalities are very prevalent in all types of corn. They have been observed in dent, flint, sweet, pop and flour corn. These abnormalities vary from a total absence of all pigment (shown in pure white or albino seedlings) to shades of light green that are almost indistinguishable from normal green. An intensive search for such chlorophyll defects surprises one by their frequent occurrence. The presence of any one of these recessive chlorophyll abnormalities in a commercial strain of corn is a serious factor in reducing yield.

At least eight factors that influence the inheritance of chlorophyll have already been reported. These are the seedling factors producing *white*, *virescent-white*, and *yellow* seedlings and the mature plant factors producing *golden*, *green-striped*, *Japonica* (both green-white and green-yellow striped), *fine-striped* and *lineate* plants. In addition there are three new factors, still under investigation, making a total of eleven factors governing the formation and expression of chlorophyll in maize.

It must not be supposed that these eleven factors comprise most of the actual number concerned in chlorophyll inheritance. They only represent the ones that are most easily handled. There are certainly many others, especially those which produce the lighter shades of green so often observed in different types of maize. But these are very difficult to work with, since their expression is greatly modified by external conditions. Such factors also would influence the vigor and yield of the plant. It is to be confidently expected that their inheritance will prove to be similar to that of the eleven factors already known.

In a previous publication[2] it has been shown that many of the chlorophyll factors are inherited independently of each other. It has also been shown that two of them (*l*, *yellow* seedlings and *g*, *golden* plants) are linked in inheritance.

Further evidence is now presented to show that some of these same chlorophyll factors are inherited independently of still other factors.

RELATION OF WHITE (ALBINO) SEEDLINGS TO ALEURONE AND ENDOSPERM FACTORS

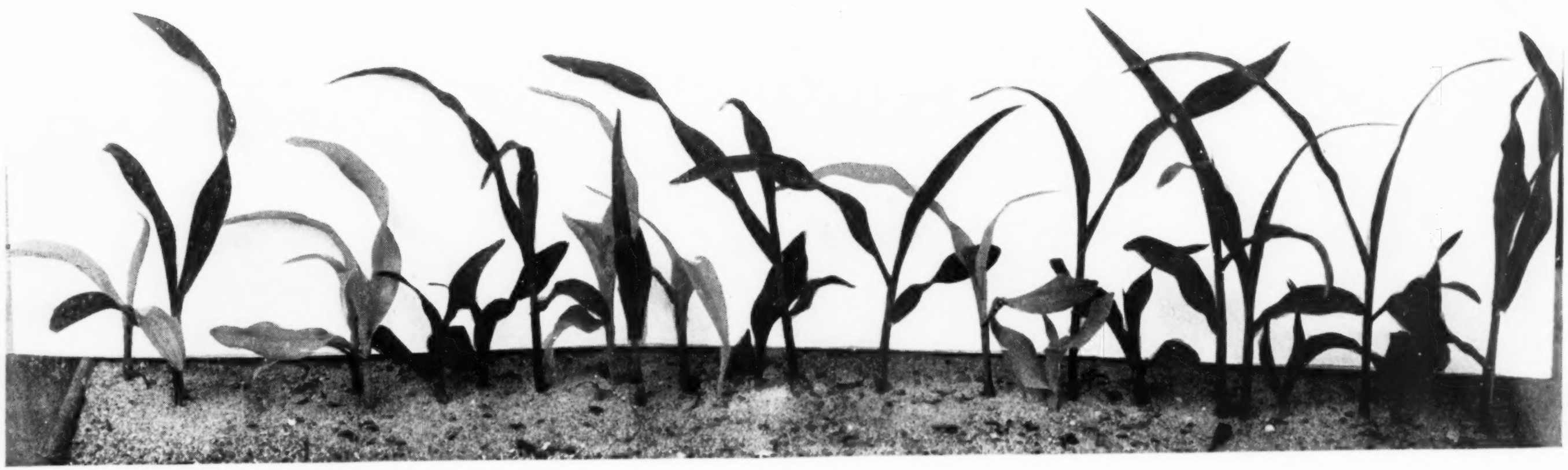
A sweet corn with colored aleurone, of the composition $iiAACCP_rP_rRR\ s_u\ s_u\ WW$, was pollinated by a plant with starchy, colorless endosperm, heterozygous for albino seedlings ($iiAACC\ P_rP_r\ rr\ S_u\ S_u\ Ww$). The F_1 endosperm was starchy and had purple aleurone color in all of the grains. The F_1 plants were all normal green.

Ten F_1 plants were self-pollinated. The F_2 grains on all showed a distinct 9:3:3:1 ratio of purple starchy, purple sugary, colorless starchy and colorless sugary grains, respectively. These four types of seed from each ear were planted separately. Among the ten F_2 seedling progenies, six produced nothing but green seedlings, while four showed a sharp segregation into green and white seedlings. The expectation in this respect was of course five and five.

The four F_2 progenies that showed segr gation are presented in Table I.

It will be noted that three of the four seedling progenies are grouped together while the fourth (2959) has been segregated and totalled separately. This was done because 2959 was a poorly developed ear that showed

[2] Lindstrom, E. W. Chlorophyll inheritance in maize. Cornell Univ. Agr. Exp. Sta. Memoir 13:1–68. 1918.



MAIZE SEEDLINGS

Showing segregation into tall green, tall yellow, dwarf green and dwarf yellow. In this particular row the proportion of these four types is 10:6:6:1 respectively. "A tall green plant which produced 75% green and 25% yellow seedlings when self-pollinated, was crossed by a dwarf plant. . . The F_1 plants of this cross were all tall and normal green. Three of them were self-pollinated and their seedling progenies tested in the greenhouse. All three showed approximately 25% dwarf seedlings, which are easily distinguished in this photograph. (Fig. 24.)

indications of pollen contamination. It is included in the table only to present all the data in this experiment.

The relations between the various factors involved in this cross can be studied best by taking two pairs of factors at a time. The interrelation between the *Ww* factor pair, governing chlorophyll inheritance and the *Su su* pair, determining starchy and sugary endosperm, will be considered first. Using the data from the three ears (2955, 2956, 2969) that show no evidence of pollen contamination, the following results are obtained when the starchy seeds (indicated by *Su*) are considered separately from the sugary (*su*) seeds:—

	Su W	*Su w*	*su W*	*su w*
Observed	507	161	155	46
Calculated	489	163	163	54

The actual or observed results approximate a 9:3:3:1 ratio very closely. The starchy seeds show a proportion of 3 green seedlings to 1 white as do the sugary seeds. In fact, the closeness of fit, as measured by *P* is .53, which indicates that there is good agreement between the facts and the hypothesis of independent Mendelian inheritance between the chlorophyll and endosperm factors.

The numbers are sufficiently large and the approximation to the theoretical expectancy is so close that we can be reasonably certain that *w* and *su* are not linked in inheritance. In other words, the albino chlorophyll factor is not on the same chromosome as the sugary endosperm factor.

ALEURONE AND CHLOROPHYLL FACTORS

If the relation between aleurone color and chlorophyll development is considered next, similar results obtain. In this case the purple aleurone grains (indicated by *R*) are classified separately from the colorless grains (*r*). The green and white seedlings resulting from these two types of seed are as follows:

	R W	*R w*	*r W*	*r w*
Observed	482	155	180	52
Calculated	489	163	163	54

Both purple and colorless seeds give approximately 75% green and 25% white seedlings, resulting in a 9:3:3:1 ratio. The calculated value for *P* is .51 which means good agreement between actual and theoretical results.

From such data we can draw the conclusion that *w* and *r* are not linked, but that the chlorophyll factor *w* is located in a different chromosome than is the aleurone factor *r*.

From the data in Table I, it can be shown that the *r* and *su* factors also are independently inherited. When grouped according to these factors the data are as follows:

	R Su	*R su*	*r Su*	*r su*
Observed	489	148	179	53
Calculated	489	163	163	54

The agreement between the actual and the theoretical results is not as good as in the preceding cases since the value

TABLE I: *F_2 Seedlings from Four Self-pollinated F_1 Plants of the Composition i i Pr Pr A A C C Rr Su su Ww**

Pedigree No.	Purple Starchy Seed		Purple Sugary Seed		Colorless Starchy Seed		Colorless Sugary Seed	
	Green	White	Green	White	Green	White	Green	White
2955	148	58	56	12	56	16	18	7
2956	74	17	18	6	20	10	6	1
2969	144	48	42	14	65	12	15	6
Total	366	123	116	32	141	38	39	14
Theoretical	367	122	122	41	122	41	41	14
2959	87	18	25	5	48	2	8	0
Total	453	141	141	37	189	40	47	14
Theoretical	448	149	149	50	149	50	50	17

*Original cross made by Mr. E. G. Anderson of the Department of Plant Breeding, New York State College of Agriculture at Cornell University.

of *P* is .40. The odds are approximately 1.5 to 1 against the observed deviations being due to chance only. Such odds are, however, not considered as seriously vitiating the hypothesis of independent inheritance of *r* and *su*.

The preceding facts demonstrate that the chlorophyll abnormality of albino seedlings is not linked with either the sugary character nor the aleurone factor *r*. Factors *w*, *su* and *r* are each on separate chromosomes.

RELATION BETWEEN DWARFNESS AND VIRESCENT-WHITE SEEDLINGS

Dwarfness in maize is a simple Mendelian recessive to the tall normal type. The virescent-white character is also a simple recessive to normal green. Virescent-white seedlings contain very little chlorophyll at first, but under favorable conditions of light and temperature, they gradually assume a light green color. It has been possible to bring some of them to maturity.

TABLE II: *Seedling Progenies from Self-pollinated Normal Green Plants Heterozygous for Tall-dwarf and Green-Virescent-white*

Pedigree No.	Tall Green	Tall Virescent-white	Dwarf Green	Dwarf Virescent-white
2862	63	24	27	11
2871	52	21	20	6
2991	57	19	16	5
2992	52	22	20	7
3017	178	52	52	11
Total	402	138	135	40
Theoretical (9:3:3:1)	402	134	134	45

Several green plants heterozygous for the virescent-white factor (*Vv*) were pollinated by homozygous green, dwarf plants. The F_1 progeny was all tall and dark green. When self-pollinated the F_1 plants produced, as was to be expected, two sorts of seedling progenies. One sort consisted entirely of green seedlings, the other segregated into green and virescent-white. Both sorts segregated into tall and dwarf seedlings. The segregation into tall green, dwarf green, tall virescent-white and dwarf virescent-white which occurred in five of the progenies was distinct, as can readily be seen in Fig. 23.

Seedling counts were made of the five progenies that showed segregation into the four classes noted above. They are recorded in Table II.

The data in this table conform closely to a 9:3:3:1 ratio and accordingly indicates that dwarfness and virescent-white chlorophyll are inherited independently of each other. Hence, the chlorophyll factor *v* is not in the same chromosome as the dwarf factor concerned in this cross.

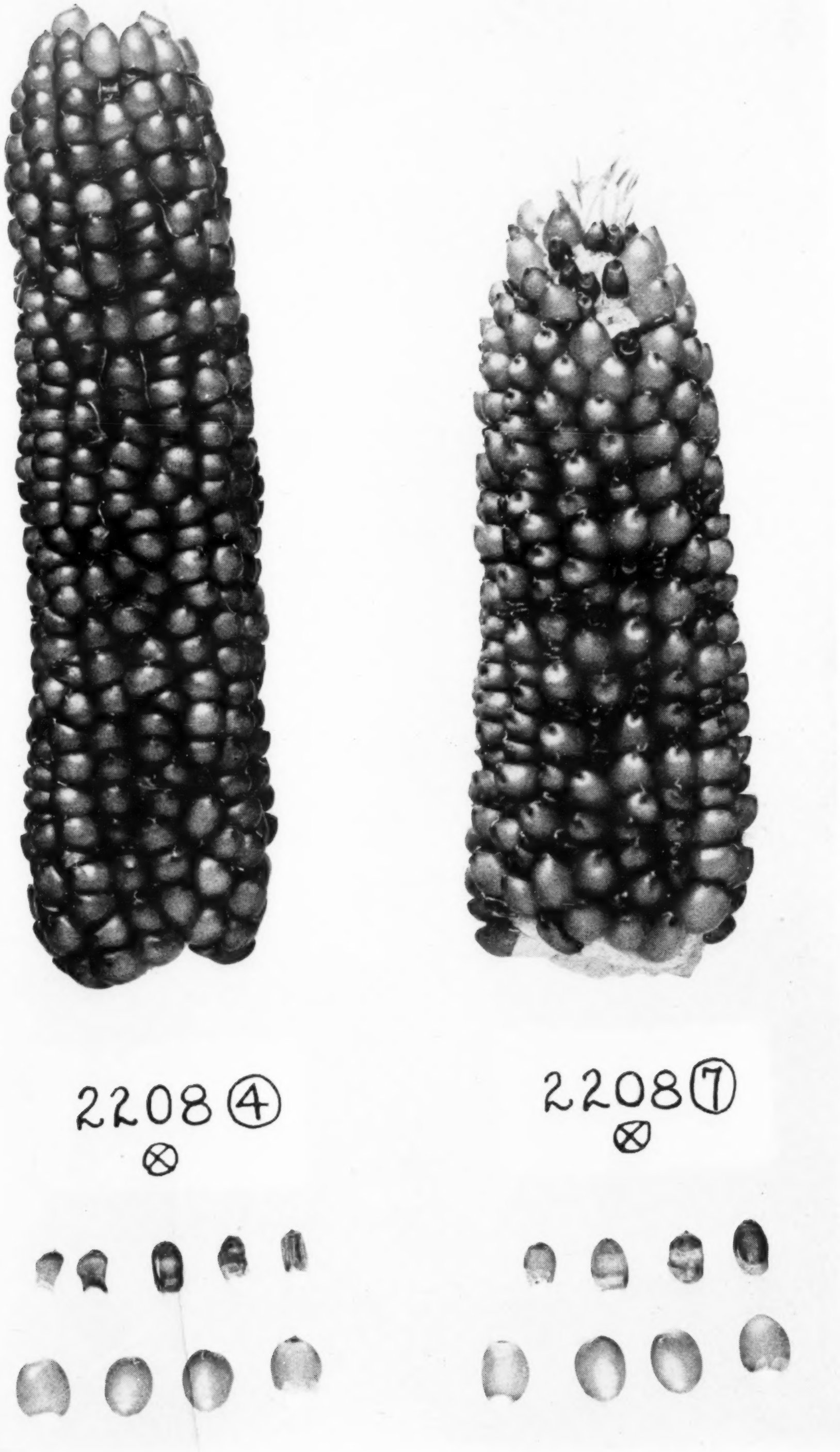
RELATION BETWEEN DWARFNESS AND XANTHOPHYLL PIGMENT

In addition to the white and virescent-white chlorophyll types, there is a third type which also is recessive to normal green. This recessive character is seen in maize seedlings that develop a distinct yellow color apparently due to the pigments xanthophyll and carotin.

A tall green plant, which produced 75% green and 25% yellow seedlings when self-pollinated, was crossed by a dwarf plant. This dwarf was of the semi-tall type with anthers in the ear. It is also a simple recessive to the tall type, but is caused by a different genetic factor than the dwarf type used in the virescent-white cross.

The F_1 plants of this cross were all tall and normal green. Three of them were self-pollinated and their seedling progenies tested in the greenhouse. All three showed approximately 25% dwarf seedlings, which are easily distinguished as can be seen from Fig. 24. Two of the progenies also segregated for the yellow seedling character, producing tall green, dwarf green, tall yellow and dwarf yellow in proportions indicated in Table III.

An analysis of this table shows that the actual results obtained do not agree very closely with the theoretical expectancy of a 9:3:3:1 ratio. The extreme classes (tall green and dwarf yellow) taken together are deficient while the middle classes (tall yellow and dwarf green) are slightly in excess



TWO SELF-POLLINATED EARS OF MAIZE

Showing approximately twenty-five percent of abortive grains. Below the labels are shown some individual abortive grains (upper rows) and some normal grains (lower rows) from these ears. (Fig. 25.)

TABLE III: *Seedling Progenies from Self-pollinated Normal Green Plants Heterozygous for Tall-dwarf and Green-Yellow Seedlings*

Pedigree No.	Tall Green	Tall Yellow	Dwarf Green	Dwarf Yellow
3006	180	72	87	22
3011	32	7	11	2
Total	212	79	98	24
Theoretical (9:3:3:1)	232	78	78	26
Calculated on 1:1.4 linkage	225	85	85	18

of the theoretical on the basis of independent assortment. If this is a case of linkage, such a situation would be expected, since the tall and yellow characters came from one parent, while the dwarf and green characters entered from the other parent of the cross.

If a linkage giving a gametic ratio of 1:1.4 is assumed, the calculated numbers agree more closely with the actual results. This indicates that the tall-yellow and dwarf-green gametes are produced approximately 1.4 times more often than the tall-green and dwarf-yellow gametes. The numbers are too small, however, for more than a suggestion of linkage. Further tests are being planned to determine this relation.

It happens that the chlorophyll factor involved in the dwarf-yellow cross is identical with the one in the dwarf-virescent-white cross discussed in the preceding section. In both cases it is the *v factor* (LLvv and llvv).

In the dwarf-virescent-white cross there was no indication of linkage between the chlorophyll factor *v* and the type of dwarf involved. In the dwarf-yellow cross however, there is a suggestion of a linkage between this same *v* and the semi-tall dwarf used there. This can only mean that the two sorts of dwarfs are genetically different and that their respective factors are located on different chromosomes.

INHERITANCE OF ABORTIVE GRAINS IN MAIZE

In connection with the study of chlorophyll factors there occurred, among several self-pollinated ears of a certain cross, a single ear that showed an appreciable number of abortive grains. At first this was thought to be the result of poor pollen or imperfect pollination. But the recurrence of the phenomenon for two years dispelled this idea and suggested that some heritable factor was involved.

Unfortunately no attempt was made in the earlier years to segregate and count the abortive grains. They were merely shelled off and planted with the normal grains. A marked deficiency in the percentage of germination was noted in these ears nevertheless.

Last season, however, four self-pollinated ears and several crosses were produced. Three of the four selfed ears showed segregation into normal and abortive grains. The fourth was an entirely normal, well developed ear. Two ears (2208-4 and 2208-7) were photographed and appear in Fig. 25.

The abortive grains are sharply distinguishable from the normal ones. They possess no trace of an embryo and no endosperm tissue has developed; they are merely shells made up of pericarp tissue. Silks are nevertheless produced on them. The abortive grains are scattered more or less evenly over the entire ear. Their distribution and their proportion to the normal grains strongly indicates that they are inherited as a simple Mendelian recessive character.

Counts were made on the three ears and the number of normal and abortive grains on each are recorded in Table IV.

TABLE IV: *Showing Segregation into Normal and Abortive Grains of Three Self-pollinated Ears*

Pedigree No.	Normal Grains	Abortive Grains	*Dev.* P. E.
2208–1	229	86	1.3
2208–4	456	161	1.0
2208–7	288	118	2.7
Total	973	365	2.8
Theoretical (3:1)	1003	335	

Among a total of 1338 grains in Table IV, 365 or 27.3% are of the abortive type. Presumably, then, we are dealing with a recessive, Mendelian factor that inhibits the formation of both embryo and endosperm.

The abortive grains occurred in a family of plants that were showing segregation into green and chlorophyll-free seedlings. It is to be expected that when the green plants of such a family are self-fertilized, a certain proportion of them will segregate in the next generation. Only four green plants (2208 (1), (2), (4), (7)) were self-pollinated and they produced nothing but pure green progenies. Four is too small a number on which to base conclusions, but it does suggest the possibility of some relation between the abortive grains and the seedlings deficient in chlorophyll.

This relation might be conceived of as a case of complete linkage between a lethal factor destroying both embryo and endosperm and another lethal factor inhibiting the formation of normal chlorophyll. Since the original F_2 generation was segregating for both the white and virescent-white seedling factors, it is impossible to judge which of the two might be concerned in such a linkage. Further tests are being planned to determine this.

There is also a possibility that we are not dealing with a case of linkage at all, but that the abortive grains are due to some physiological interrelation of the chlorophyll factors. Since, however, all the known chlorophyll abnormalities have been tested against each other and have reacted and segregated as ordinary Mendelian factors, it does not seem re sonable to suppose that they would, in themselves, have any such radical effect as to destroy both embryo and endosperm.

The relation between the abortive-grain character and inbreeding is similar to that of the other recessive characters mentioned in the first paragraph of this article. If present in a strain of maize, although they might be unsuspected, being hidden by the dominant, normal allelomorph, these abortive grains would begin to appear when the strain was inbred. This would decrease the yield of such a strain seriously. The abortive-grains could be eliminated, with some difficulty however, but if any favorable characters were closely linked with them, they too would be eliminated.

SUMMARY

Certain striking chlorophyll abnormalities are shown by breeding evidence to be distributed in several different chromosomes of maize. From this it is to be inferred that other less pronounced deficiencies of chlorophyll are distributed in a similar manner. The latter especially are common in commercial fields of corn and presumably are responsible for decreasing or limiting the productivity of the plant to some extent. They would naturally be isolated and removed in an intensive system of selective inbreeding, since they are recessive in nature. Being distributed on different chromosomes their elimination would tend also to remove some of the more favorable factors which, being on the same chromosomes, would naturally follow the defective factors in inheritance. In this manner, it is very likely that continuous inbreeding removes favorable as well as unfavorable factors from the original stock.

To succeed in a system of maize inbreeding then, it is essential to begin with the best source of material available, a source that is as free of abnormalities and defects as possible. It is probable that inbreeding of such stock might be carried out with very little loss of stature, yield or fertility and would at the same time improve the uniformity of the type.

MUTATIONS IN MUCORS[1]

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THE theory of mutations has played an increasing rôle in experimental evolution since its enunciation some twenty years ago. Sudden germinal changes, large or small in amount, have been the basis of perhaps the most fundamental work in modern genetics. It is natural that mutations should have been first sought for and found primarily in higher organisms, and in connection with the sexual reproduction which is characteristic of such forms. It became evident later that mutations could not be confined to cells associated with sexual reproduction, but, as shown by the somatic mutations involved in bud sports in plants, and in similar less common phenomena in animals, they may occur in cells in which sexual processes are not involved. They have been found in lowly organized plants and animals in which nonsexual reproduction is the rule or in which sexual reproduction is not known to occur.

The mucors are a fungous group in which multiplication is brought about chiefly by nonsexual spores produced in sporangia. Sexually formed zygospores are rarely found in most forms. There are two main groups as regards their sexual reproduction:—dioecious forms and hermaphrodites. The sexual races of the dioecious forms are in the main similar in appearance, and the uniting sex cells or gametes are apparently morphologically equivalent. For this reason, the terms plus and minus have been applied to their opposite sexes instead of the terms male and female used in reference to the morphologically distinct sexes in higher forms. In many cases it has been possible to obtain a sexual reaction, called "imperfect hybridization," between plus and minus races of different species. This imperfect hybridization reaction has also been used in testing the sexual tendencies of hermaphrodites and their mutants.

It is in a species of the hermaphrodites (Mucor genevensis) that the mutations discussed in the present paper have been found. Races of this species from three different sources have been kept running in vegetatively propagated pure lines for 19 years. The species was studied in 1913 with the hope of inducing germinal changes by subjecting its vegetative growth or mycelium to various physical and chemical stimuli. Before concluding that any variation found after subjecting the mycelium to a given stimulus was in fact brought about by this stimulus, it was necessary to discover what, if any, variations the fungus would produce under normal conditions. So many variants were discovered, however, in this preliminary study, where no special stimuli were applied, that extensive investigations have not yet been attempted as to the range of variations under abnormal conditions.

METHOD OF GROWING MUCORS

The method of growing these mucors is relatively simple. To be sure that there is no doubt as to the purity of the stock with which one starts, it is desirable to obtain a culture from a single vegetative spore. This single-spore culture is grown in a test tube and, in addition to slow-germinating zygospores, produces numerous sporangia containing thousands of nonsexual spores. These sporangiospores are mixed with water and the spore mixture diluted until a platinum loop will con-

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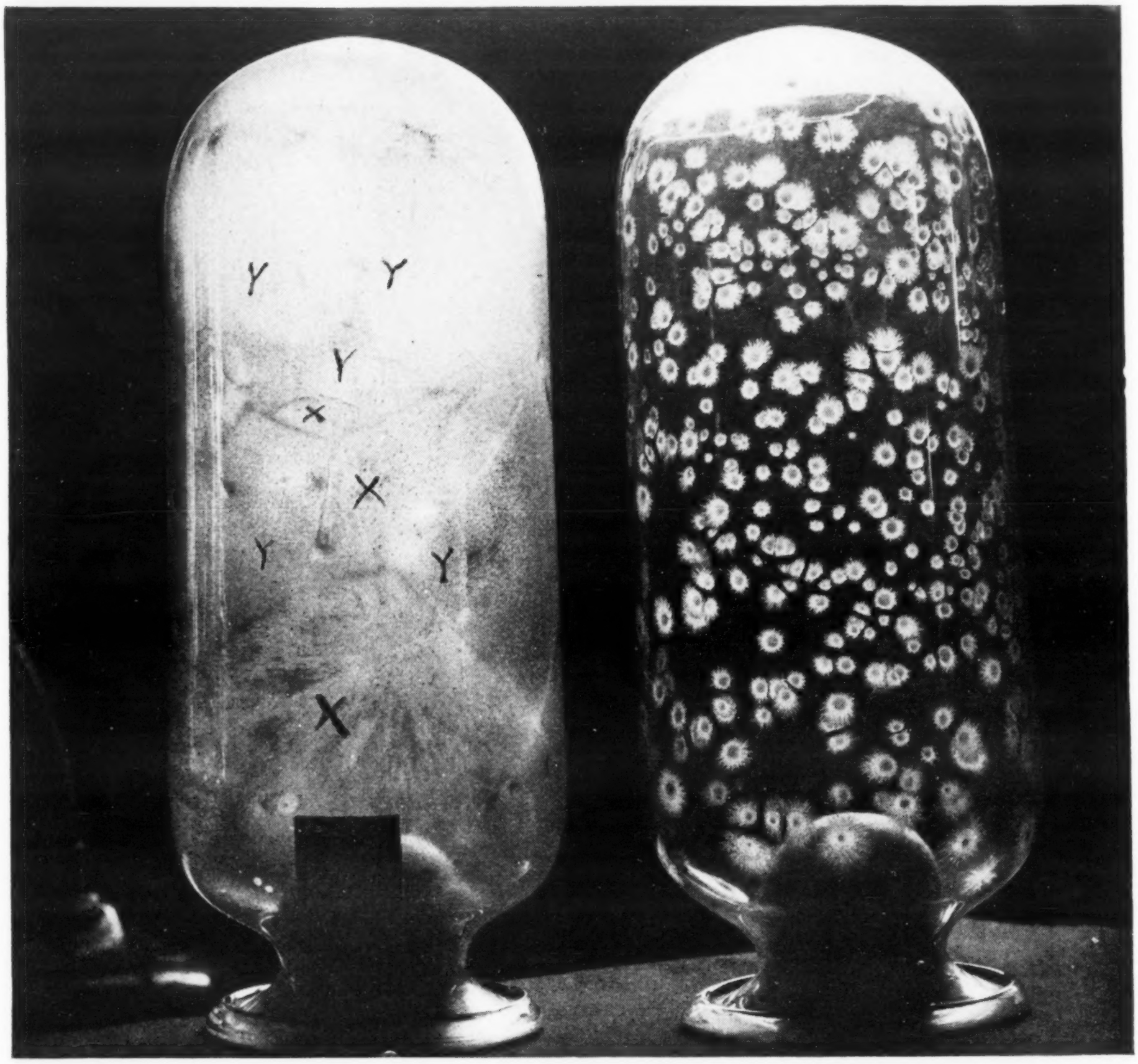
[1] A preliminary report of mutations in mucors was given in Year Book of the Carnegie Institution of Washington XII, 104–105, 1913 and presented before the Amer. Soc. of Naturalists, Dec., 1914.



SPECIMEN JARS USED IN ISOLATION CULTURES

The Dwarf true-breeding mutant is shown in the jar at the right, and on the left is shown mutant "X," an unstable mutant reverting to normal type "Y." The "Dwarf" is eleven days old "and its slowness of growth can be seen in comparison with the seven day old culture on the left. (Fig. 26.)

tain the proper number of spores as determined by examination under the microscope. The requisite number of spores are transferred with the loop to a tube of melted nutrient agar, and the agar then poured into an inverted specimen jar used as a roll tube shown in Fig. 26. By proper manipulation under the water tap, the agar is hardened, thus holding the spores uniformly scattered in a thin layer inside the tube. It goes without saying that the various steps in this process should be carried on with regard to the precautions necessary to prevent contamination with foreign spores. By the second day the spores have germinated and produced mycelial colonies which rapidly increase in size and eventually cover the available nutrient. Several hundred colonies can be readily observed in a quart sized tube.

In such an isolation culture just described, it is usual to find a few of the colonies which differ more or less in appearance from the normal growth expected for the species. The difference may be in the color or compactness of growth of the mycelium, in the lengths of the sporangium stalks, or in the size and abundance of the zygospores which are later produced, or in a

number of other characters, but most commonly in the reduced size of the colonies. The aberrant colonies may be transferred uncontaminated to test tubes before the spores are produced or their spores may be used in making a new isolation in a second roll tube. In all, somewhat over 38,000 colonies from individual sporangiospores have been inspected and a relatively large number of variants of different degrees of distinctness have been obtained. The history of nearly all of these mutants is similar in that the mutants tend eventually to revert to the normal type. Two, however, have seemed more stable than the rest.

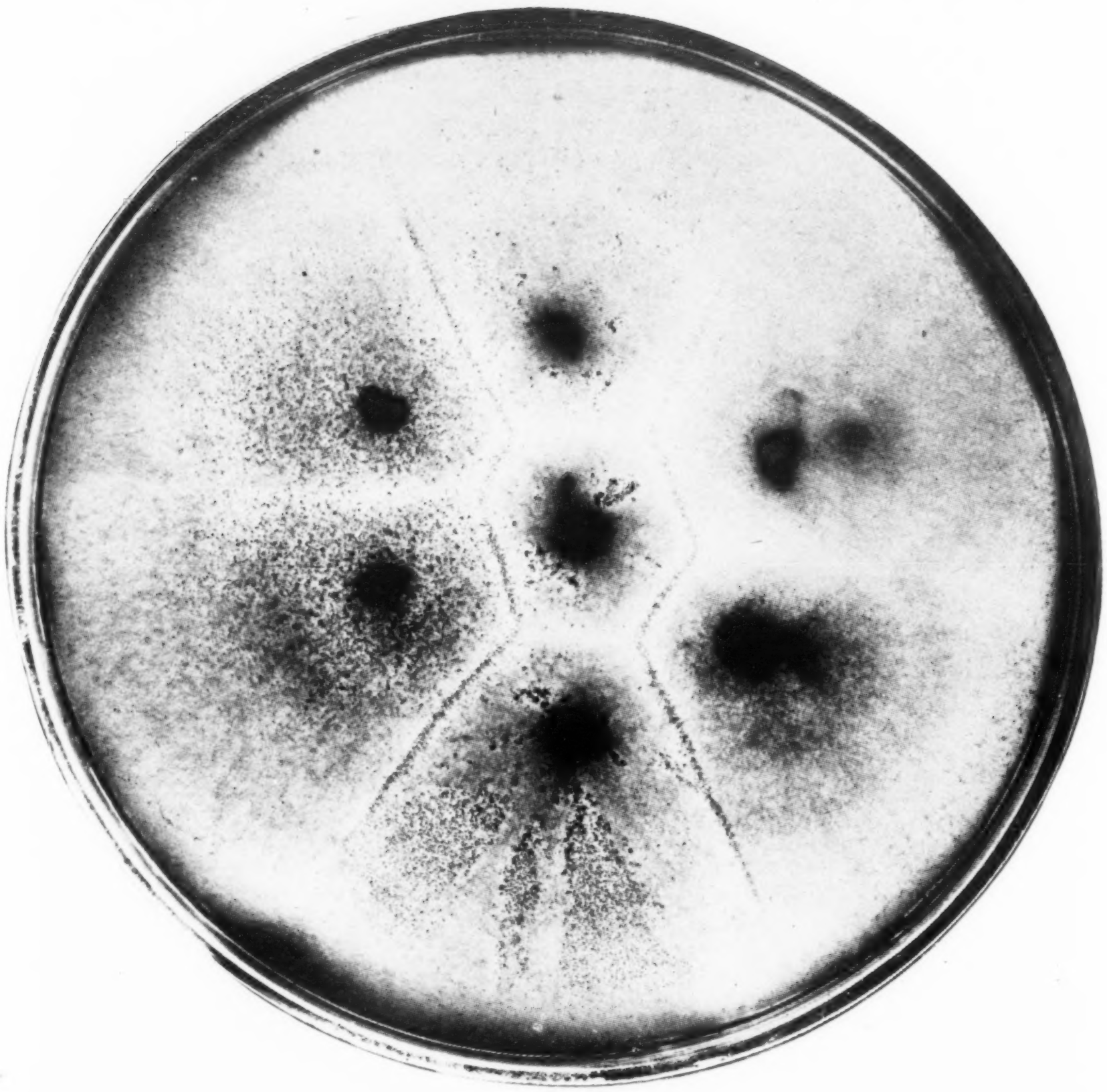
A FIXED DWARF MUTANT FOUND

A mutant which can conveniently be called the "Dwarf" was found in March, 1913 in an isolation of spores from a single test tube culture of the normal stock. Among 1015 individuals, a single colony was noticeably smaller than the rest and different from its neighbors in the density of its mycelium and the ragged edges of its growth. Transfers of the mycelium to test tubes and continued cultivation for nearly seven years on a variety of media in gross and isolation cultures make it apparent that the mutant is fixed and constant. Its characteristic appearance, in an isolation culture, is shown in the right hand tube in Fig. 26. This is eleven days old, and its slowness of growth can be seen in comparison with the seven day old culture on the left, especially with the lower colony marked "X" which had more room for extension than its neighbors. Perhaps the most striking peculiarity of the Dwarf is its lack of definitely formed spores characteristic of the group and found in all our other mutants. The mycelium is granular and readily breaks up into bits of the mycelium, so that isolation cultures from these fragments can be made, but no sporangia have ever been observed. The difference in size of the colonies in the tube photographed may be due to a difference in the size of the fragments from which they grew. The granular nature of its vegetative growth is merely a more pronounced expression of a tendency already present in the parent stock especially when grown in sugar solutions. Like the normal stock, the Dwarf also is able to take active part in alcoholic fermentation.

Zygospores, normally characteristic of this hermaphroditic species, are also entirely lacking, as might be expected from so weak a growth. For the same reason perhaps, it fails to give any sexual reaction with plus and minus races of a test dioecious species. The inhibiting effect upon growth of adjacent colonies may be noted in the photograph by their flattened outlines and the clear space between, where otherwise they would grow into contact. Instances where colonies seem to overlap are due to colonies showing through from the other side of the tube.

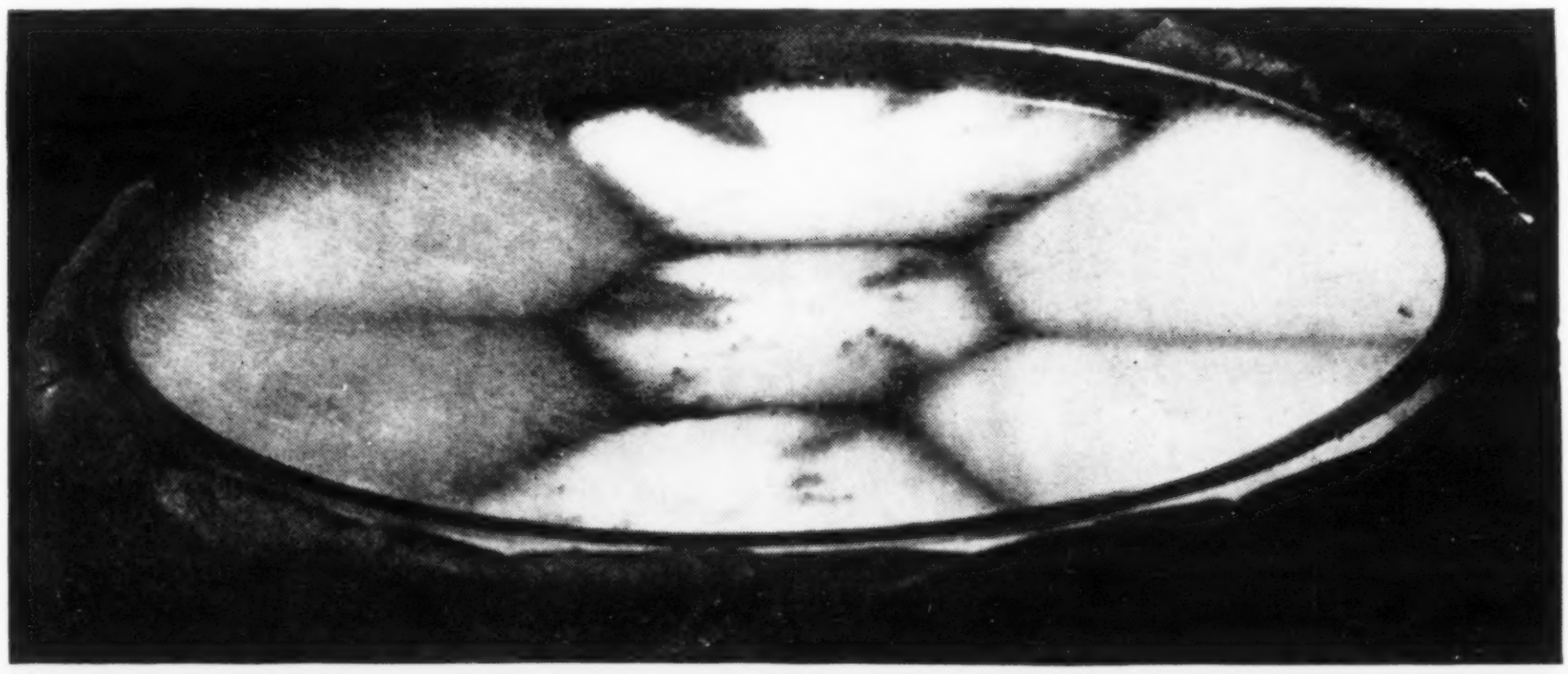
A MUTANT FROM A COLONY LACKING ZYGOSPORES

The second mutant to be considered which appears to breed true was found February 22, 1913 in a two weeks old isolation culture of 265 colonies. This single colony, labelled A1, entirely lacked zygospores which thickly dotted all the other colonies in the series. It was freed from its zygosporic neighbors, with which its sporangia were intermingled, by streaking its spores on nutrient agar in a Petri dish culture. Some of the colonies produced zygospores and were considered to be from spores of other adjacent colonies. Some were entirely free from zygospores. One of the latter was transferred to a tube culture while young and labelled A2. From A2 an isolation culture was made on March 7, and produced 4631 colonies, all of which lacked zygospores. One of these colonies (A3) was used in making another isolation culture and yielded 24 colonies again, all without zygospores. The mutant race has been continued in test tube culture since 1913 and at the present writing has reached the 16th nonsexual generation. Tube A16 is distinctly different from other races of



PETRI DISH CULTURE PHOTOGRAPHED BY TRANSMITTED LIGHT

The small black dots are sexual spores (Zygospores); the large dark areas are places where innoculations were made. The two left hand colonies are the normal race with numerous hermaphroditic zygospores The central row of three colonies are mutant "X" with large zygospores; the two right hand colonies are mutant "D" with only an occasional zygospore or none. Mutant "X" has a plus sexual tendency and hence forms lines of zygospores in contact with mutant "D" and the normal race, both of which have a minus tendency. (Fig. 27.)



CULTURE PHOTOGRAPHED BY REFLECTED LIGHT

The same arrangement of races as in Fig. 27 above. (Fig. 28.)

this species, primarily on account of the light appearance of growth due to the lack of zygospores. The ability to form hermaphroditic zygospores did not seem to have been entirely lost in 1913, however, since on more suitable nutrient than is available in the thin layer in an isolation tube, zygospores were occasionally produced, although in very small numbers. At the present writing (February, 1920), it fails to produce zygospores on the nutrients tested.

Tests made in 1913 of the A3 generation showed that the mutant had a minus sexual tendency since it gave good reactions with the plus races of two different dioecious species. In addition, it formed a line of zygospores with the "X" mutant known to have a plus tendency. This will be discussed in a later paragraph.

That it was not entirely lacking in the plus sex was further shown by its reaction, although weak, with a minus race of one of the dioecious test species. The mutant "A" therefore cannot be considered an example of complete transformation from a hermaphroditic into a dioecious species although it may show a tendency in this direction. It may be added that the "A" mutant has recently given rise to a striking new form "F" characterized by a low, white, felted, aerial growth and a scanty production of zygospores. It has been carried to only a few generations but so far has remained constant.

The "Dwarf" and Mutant "A" are the only examples of true-breeding mutations so far investigated in the species. Further study may show that even these have the power of reverting at times. Those discussed in the following paragraphs are examples of the more common type of reverting mutations.

MUTANTS WHICH HAVE NOT REMAINED CONSTANT

In Figs. 27 and 28 are shown two mutant races, "X" and "D," which have not remained constant under cultivation. The two colonies at the left in each figure are the normal stock; the three colonies in the central row are the "X" mutant and the two colonies at the right are the "D" mutant. The photograph shown in Fig. 27 was taken by transmitted light and shows the hermaphroditic zygospores as small black dots; the large dark areas are the places where the inoculations were made. The photograph in Fig. 28 was taken by reflected light and shows better than does Fig. 27 the differences in habit of growth between the three races.

Mutant "X" has a lower, whiter growth than the normal race. Its sporangia, as well as its zygospores, are less abund nt and the latter are somewhat larger than normal and tend to be arranged in groups, which often form dark sectors radiating from the point of inoculation. Its greatest interest lies in the fact that it forms a line of zygospores with the normal race on its left as well as with the "D" mutant on the right, as shown in Fig. 27 and less well in Fig. 26. It was this ability to form lines of zygospores with adjacent colonies that attracted our attention to its first appearance in an isolation culture of a strongly zygosporic mutant consisting of 41 colonies. Ordinarily, as mentioned under the Dwarf mutant, colonies exercise some inhibitory action toward one another which retards their growth on adjacent sides and prevents their meeting when the nutrient is thin, as in an isolation culture. The inhibitory action is absent and the colonies meet when they are of opposite sexual tendencies. This seems to be the case with mutant "X" and its parent race. The normal race (called "Y") gives a strong reaction with plus test races of dioecious species and is therefore a hermaphrodite with a minus tendency, while mutant "X" gives a strong reaction with minus test races and is therefore a hermaphrodite with a plus tendency. In a similar way mutant "A" and mutant "D" have been shown to be hermaphrodites with a minus tendency. Mutant "D" formed at first a yellowish dense growth almost entirely devoid of zygospores. By continued cultivation

it seems to have lost its distinctive characteristics.

The history of the mutant "X" is given in the Table on page 284. In a series of isolation cultures in 1914 the mutant bred practically true with only three possible reversions to normal out of nearly 1500 colonies. In the 17th generation in 1916 the mutant seemed to have entirely reverted. It was regained, however, from a culture of an earlier generation and by a series of isolations its ability to throw offspring like itself was again increased. In 1917, after a few generations grown in test tube cultures, the mutant again appeared to have entirely reverted to the normal parental type and could not be regained.

At two other times in this species have mutations been observed which form lines of zygospores with the nornal stock: once in an isolation culture in 1916 and once ten years earlier at the germination of the zygospores. Other mutants tested have shown a minus tendency like the parent stock.

A STRIKING MUTANT FORM

One of the most striking mutant forms appeared as a small warty colony in an isolation culture of 949 colonies. A microscopic examination showed that the colony was composed exclusively of a mass of yeast-like cells somewhat similar to those that are formed when the normal mycelium of this species is submerged in a sugar solution and takes part in alcoholic fermentation. An isolation made from this original colony gave predominatingly yeast-like colonies with only a few normal colonies. At first no filaments were found and the accumulation of yeast-like cells formed a warty mound above the surface of the agar. Often the drops of water exuding from the agar in running down the inside of the tube would carry with them the yeast-like cells of the mutant and form streaks of secondary "yeast" colonies. Later each colony gave rise to a few normal filaments, the further rapid growth of which filled the culture and covered over the warty mutants. During April, 1913, a series of four isolation cultures were made of the "yeast" mutant, resulting in 721 "yeast" colonies to 423 early reverting colonies. The records were taken on the fourth or fifth day. Eventually even the typical "yeast" colonies reverted. During August and September 1914, an attempt was made to regain the "yeast" condition from five test tube cultures which had originally contained "yeasts." A total of 5,995 colonies were examined from these tubes, but the "yeast" mutant could not be recovered. Reversion in this mutant takes place regularly in the mycelium. In other mutants reversion is apparently more common at the formation of spores.

The "X" and the "A" mutants are of especial interest from the standpoint of sexual differentiation. On account of its freedom from zygospores and its relatively strong reaction with plus test races, mutant "A," if found alone, would appear to be an unmated minus race of some dioecious species. Its very weak reaction with certain minus races might easily be missed. If mutant "X," which is a mutant in the plus direction, had been likewise devoid of zygospores and found to conjugate with mutant "A," as it actually did, one would have felt justified in considering "X" and "A" as the mated plus and minus races of a dioecious species. It is possible that in nature dioecious races may have arisen from hermaphrodites through mutations which have carried the sexual differentiation farther than was observed in our two mutants.

Burgeff has obtained mutations in the dioecious mucor genus Phycomyces. The mucors are multinucleate, normally without cross walls in the vegetative mycelium. Mutations, he considers, affect only a part of the nuclei. The more rapid division of the normal nuclei in these mixo-chimeras, as he calls the variants, would account for the reversions which almost always take place. It is possible that our reverting mutants in the hermaphroditic *Mucor genevensis* are in fact

mixo-chimeras, and that it may be possible to obtain them in pure races as Burgeff has done in Phycomyces through the germination of the zygospores.

The individual mutants considered in the present paper are representative of many variant forms that have arisen by mutation in the nonsexually propagated races of *Mucor genevensis*. They add to the evidence, already obtained from other groups, that mutations are not restricted to processes involved in sexual reproduction.

HISTORY OF "X" MUTANT

(Y represents colonies normal to X)

September, 1913	X1 First colony of mutant X	
" "	X2 Isolation culture	X and Y types present.
" "	X3 Test tube culture of an X colony from X2	
Aug.–Sept., 1914	X4 Isolation from X3	96X : 119Y
" " "	Y5 Tube from a Y colony of X4	
" " "	X5 " " " X " " "	
" " "	Y6 Isolation from Y5	0X : 481Y
" " "	X6 " " X5	512X : 3Y (?)
" " "	X7 " " X6	625X : 0Y
" " "	X8 " " X7	316X : 0Y
	X9–X13 Series of test tube cultures	
February, 1915	X14 Isolation from X13	115X : 3Y
	X15 & X16 test tube cultures	
Feb.–April, 1916	X17 Isolation from X16	0X : 204Y
" " "	Xa12 " " X11	5X : 56Y
" " "	Xa13 " " Xa12	16X : 1Y
" " "	Xa14 " " Xa13	678X : 3Y
	Xa15–Xa17 Test tube cultures	
July, 1917	Xa18 Isolation from Xa17	0X : 207Y
" "	Xa17 " " Xa16	0X : 473Y

A RANDOM TEST IN THE THEORY OF PROTECTIVE COLORATION

FREDERICK ADAMS WOODS

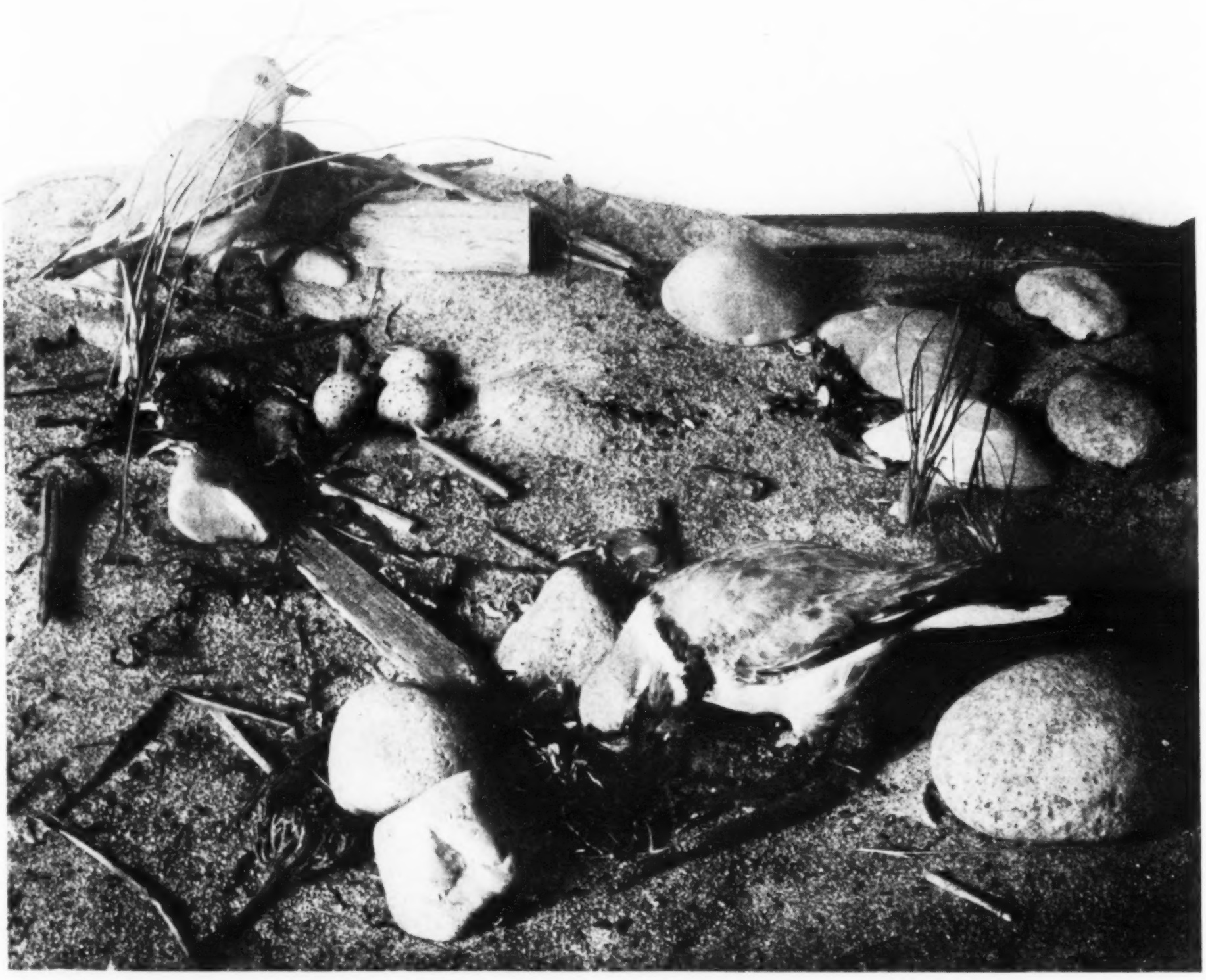
UNTIL Abbott Thayer had developed the theory, no one supposed that the bright and often dazzling colors of birds and other animals were in many instances a device to render these creatures not *more* but *less* conspicuous. Rem mbrance of the wide introduction of camouflage and dazzle-painting during the late war will doubtless do much to convince the skeptical of the essential truths of Thayer's theories—discoveries which were in their essence optical, and did not necessarily involve learned discussions in natural history.

In Thayer's elaborate and magnificent book on the subject of protective coloration, a large number of black-and-white, and sometimes colored, pictures are presented by way of proof, but inasmuch as the authors[1] have been accused of being over-zealous in finding support for their theory, some impartially, and accidentally acquired evidence is not without interest.

Such evidence can now be supplied by museum material. In the old days, natural history museums were dismal places to visit. Stuffed animals, usually moth-eaten, were kept in dark and dusty cases, scientifically labeled and seldom seen. Now we have in many of the larger museums beautifully and accurately constructed artificial backgrounds as suitable settings for the wild life exhibited (as if in nature) and surrounded by natural objects—leaves, twigs, stones, and sand.

The four pictures, here presented, were taken in the Museum of the Bos-

[1] Thayer, G. H. and A. H., "Concealing Coloration in the Animal Kingdom," 1909.



PIPING PLOVER ON SAND AND ROCKS

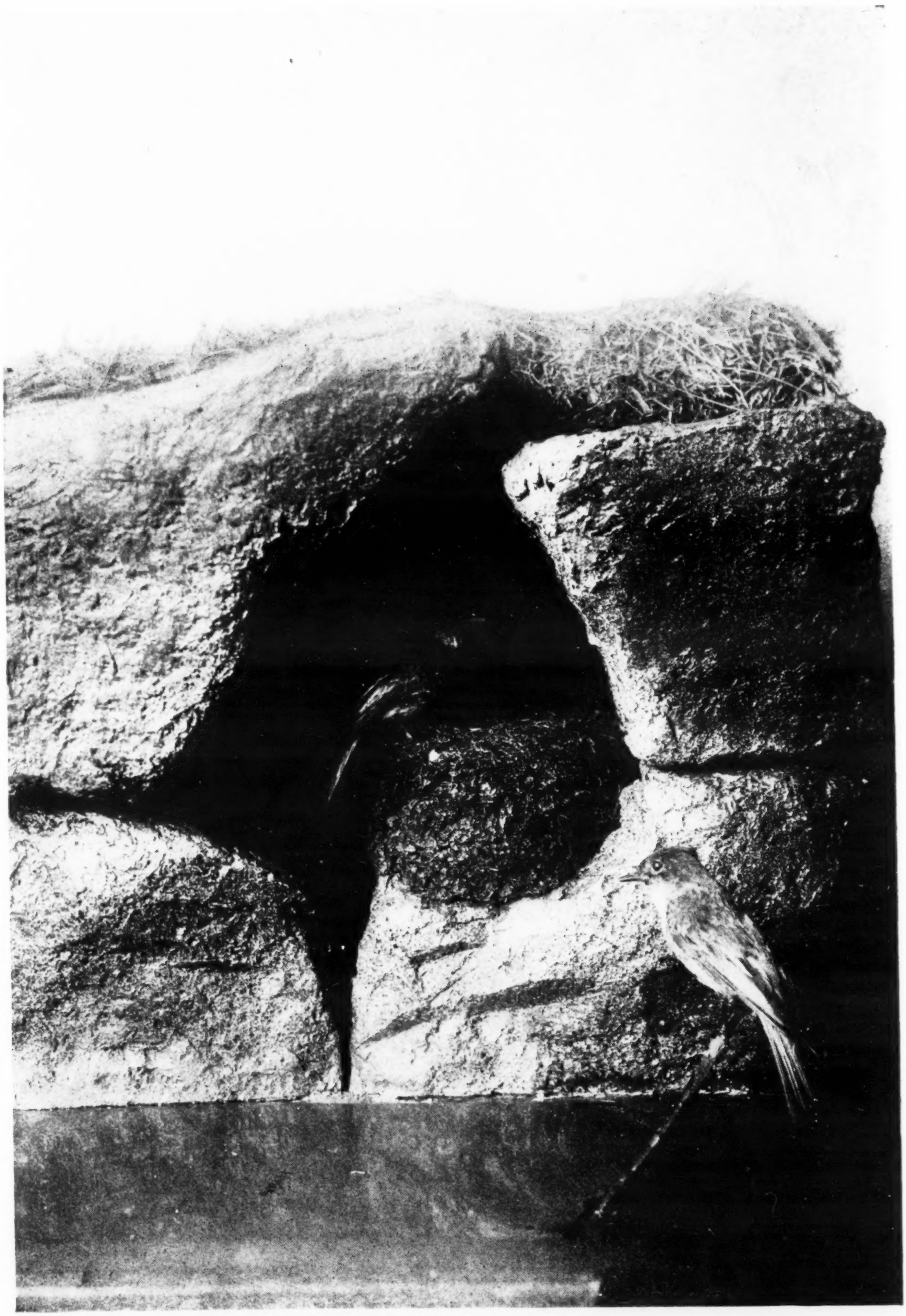
Piping Plover are well concealed by their white and pale grey coloration. The eggs resemble stones and are hard to recognize. The dark band on the neck of the bird in the centre of the picture resembles the shadow on the adjoining rock. (From an exhibition case in the Boston Society of Natural History.) (Fig. 29.)

ton Society of Natural History, as a confirmatory test—one that should be presumably impartial, since no rearrangements were made. The birds were taken just as they were placed in the cabinets, except that the frames as a whole were tipped at an angle, in order to facilitate the photographic work. All of these except the Phoebe are also represented in Abbott Thayer's book.

One of the birds, a whippoorwill, is artificially outlined against the white sheet used as a background. The head of a plover is easily detected for the same reason, but whenever the birds appear against their natural backgrounds their concealment is excellent and the test indicates that the Thayers did not strain a point by arranging their birds in especially favorable attitudes.

A WELL CONCEALED BIRD

This bird, a nighthawk, is exceedingly well concealed, its yellowish brown plumage merging with the dead leaves and twigs. The eggs are spotted and colored but are not invisible. (From an exhibition case in the Boston Society of Natural History.) (Fig. 30.)



A PHOEBE

This bird is a good example of protective coloration. It builds its dark green nest among dark green rocks near the water and its color resembles its surroundings. (From an exhibition case in the Boston Society of Natural History.) (Fig. 31.)

A WHIPPOORWILL

The female on the ground is almost invisible, its color closely resembling the dried leaves. Its eggs are white, in contrast to those of the nighthawk. The white background here is artificial. (From an exhibition case in the Boston Society of Natural History.) (Fig. 32.)